AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 45 No. 7 JULY 1955 PRICE: 3s. 6d

WE HAVE A WAY WITH BRAKES

Into our Research Department at Cleckheaton come all manner of problems to do with brakes. Here we can reproduce the actual service conditions under which brakes operate and check performance on machines and delicate instruments which leave no room for guesswork.

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When high performance counts

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"The most useful piece of equipment we have"

Typical of many such remarks applied to the Wickman Optical Profile Grinding Machine is this considered statement made by a tool-room supervisor recently. And calling to mind some of the complicated and uncertain grinding improvisations that were previously the order of the day, his satisfaction can be understood.

For the production of intricate profiles in hardened steel or tungsten carbide, for gauges, form tools and punches and split dies for press tools, there is no simpler system, nor one which offers such universal application.

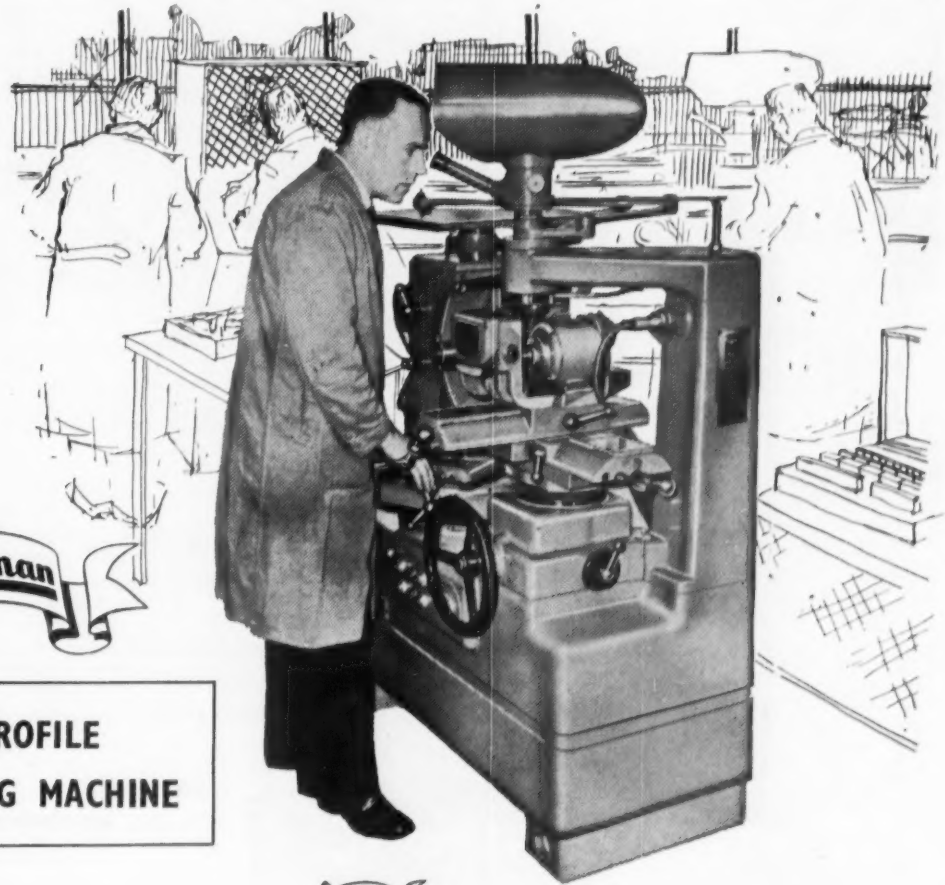
The preparation of a pencil drawing of the contour 50 times larger than the form to be produced is the only preparatory work required. This is applied to the drawing table on the machine and used in conjunction with the pantograph system to trace the required profile.

A microscope is incorporated in the final arm of the pantograph whose path follows the tracing point, outlining the correct profile, the path of the grinding wheel then being traversed by manual control to the cross hair lines of the projection unit.

Accuracy of the work is not affected by wheel wear, and specially shaped wheels are not required:

INTRICATE PROFILES ACCURATELY REPRODUCED.

By the combined use of the compound slides, set to vernier scales, and the pantograph positioned microscope, profiles can be simply and positively produced to limits of accuracy frequently closer than 5/10th of a 'thou'.



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OPTICAL PROFILE GRINDING MACHINE

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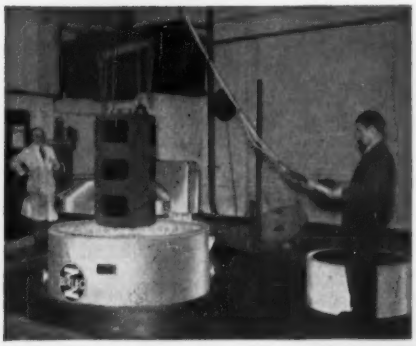
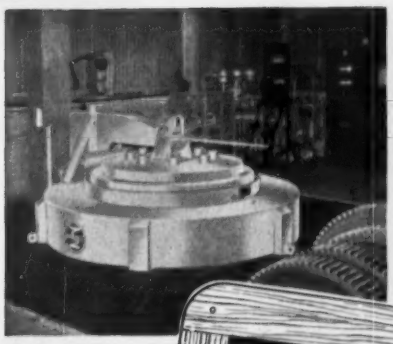


GAS CARBURISING

... that's correct



top: two 100 kW units, 27" diam. x 54", for heavy gear parts.

centre left: gas fired unit, 48" diameter x 48" deep, using endothermic atmosphere generator.

centre right: the smallest standard pit unit; 40 kW furnace with drip-feed carburising system.

bottom: two 65 kW furnaces, 24" diameter x 42" deep, with (rear) pit tempering furnace and (front) the gas atmosphere generator.

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- Standard charge space dimensions vary upwards from 18" diameter X 30" deep to 48" diameter × 48" deep.

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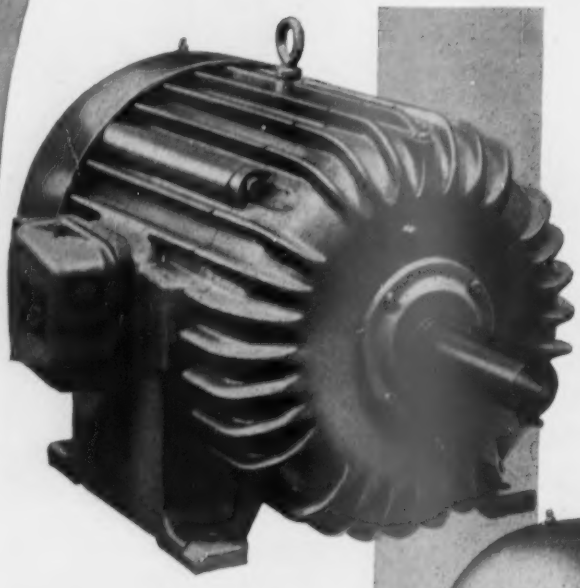
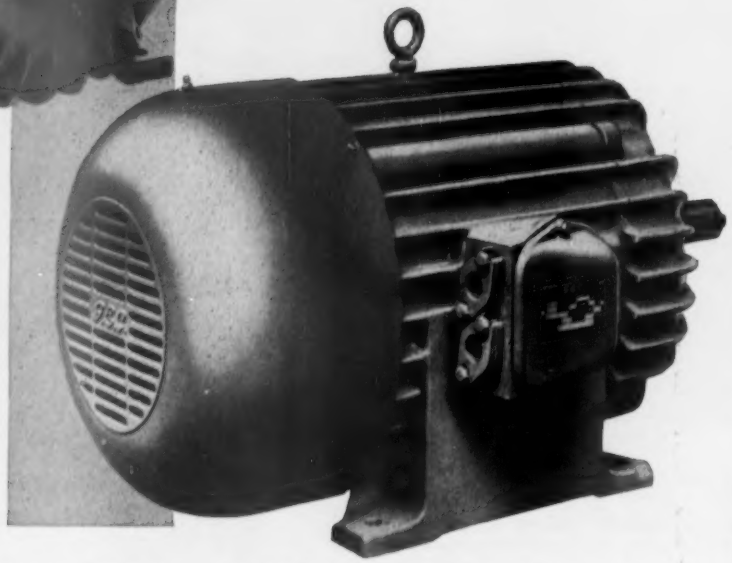


G.E.C. MOTORS



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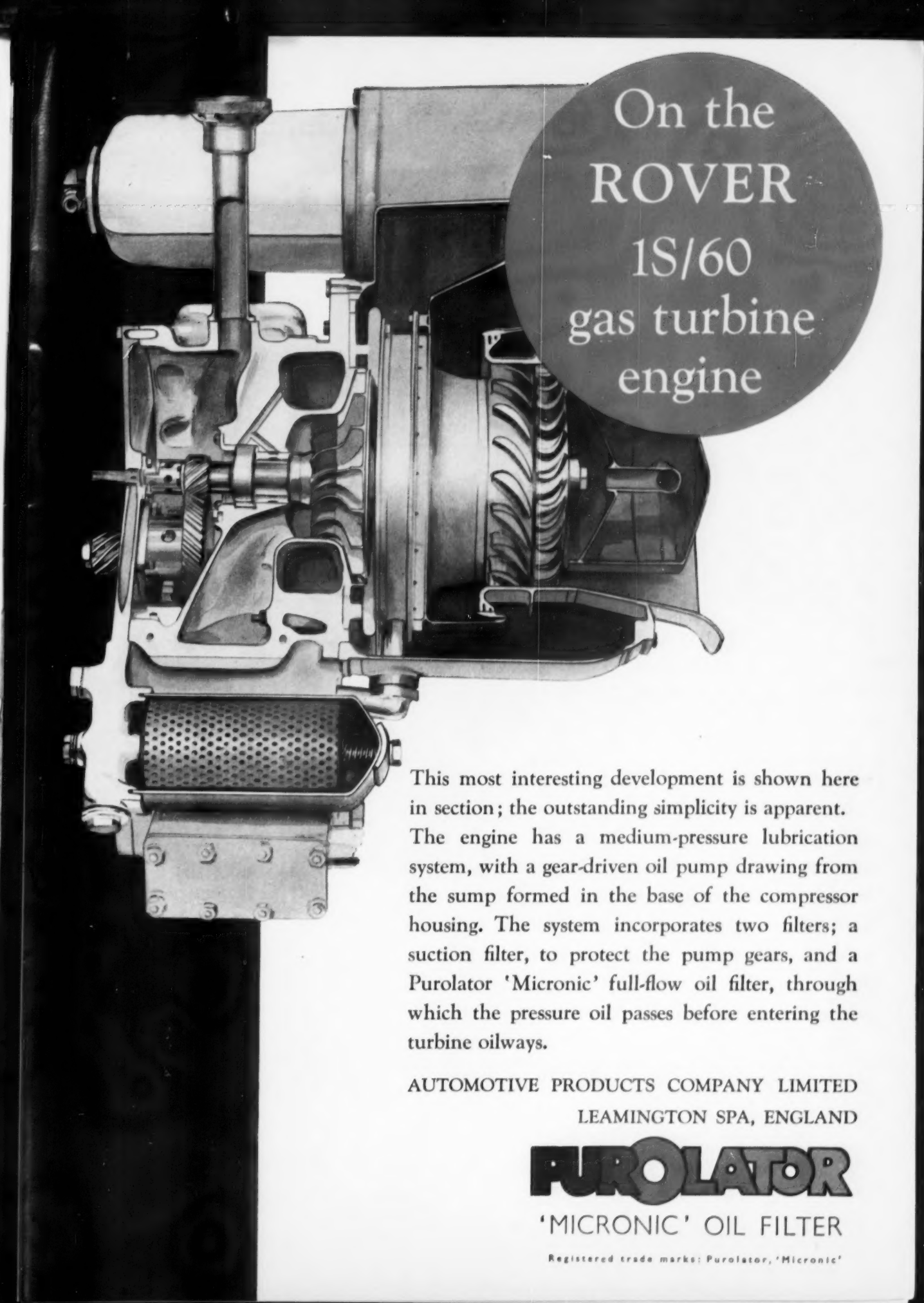

On the ROVER 1S/60 gas turbine engine

This most interesting development is shown here in section; the outstanding simplicity is apparent. The engine has a medium-pressure lubrication system, with a gear-driven oil pump drawing from the sump formed in the base of the compressor housing. The system incorporates two filters; a suction filter, to protect the pump gears, and a Purolator 'Micronic' full-flow oil filter, through which the pressure oil passes before entering the turbine oilways.

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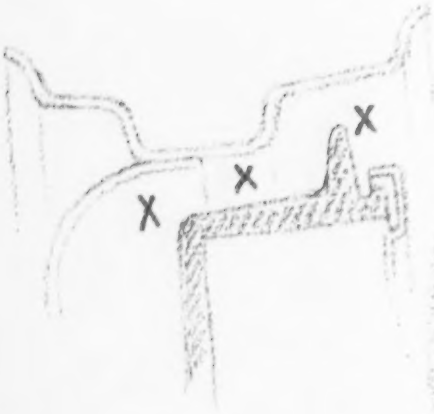
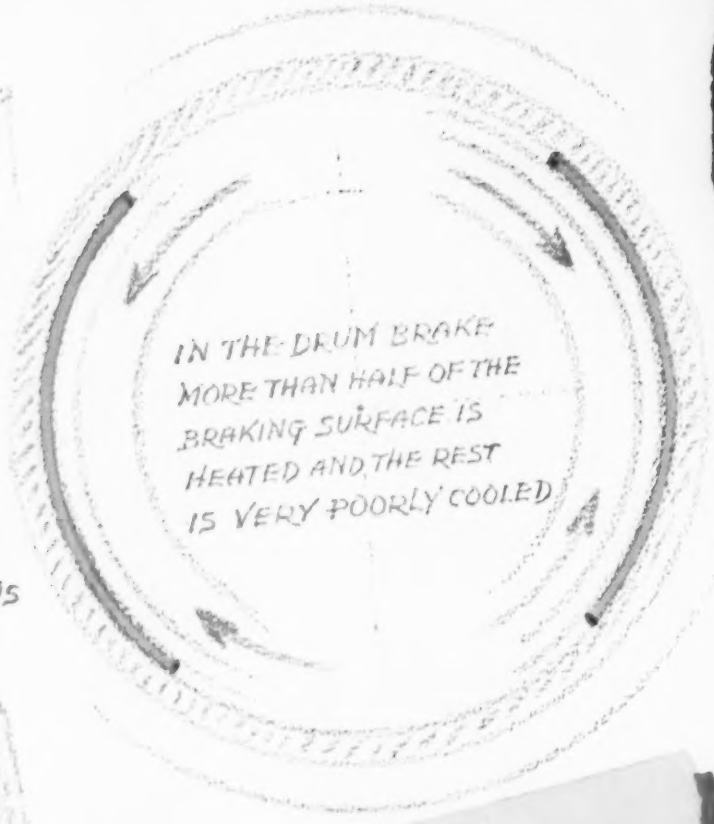


IN MODERN CLOSE-BUILT DESIGNS THERE IS PRECIOUS LITTLE COOLING OF DRUM



IN A DRUM BRAKE THE INSIDE IS HOT AND RELIES FOR COOLING ON CONDUCTION TO THE OUTSIDE, GENERALLY MASKED

The ideal

What we'd all like to see is a large braking surface, with only a low temperature rise, and that surface to be well cooled.

BRAKES: Work into heat

It has become clearly apparent in the last few years that the ordinary type of drum brake, when fitted in the conventional manner to extremely fast cars, is beginning to show signs of reaching its upper limit of performance. The problem is chiefly, but not entirely, one of energy dispersal, coupled with the vital need for avoiding loss of braking effort on a succession of drastic stops.

The modern trend, to smaller wheels and tyres of large cross-section, limits the space in which a brake can be housed, and decreases the flow of air to the brake, and modern cowling still further restricts the flow. Special efforts have been made to augment the air flow to the brakes, but these manoeuvres are helpful over only a narrow range, for the problem lies deeper. The arrangement of the ordinary brake is such that whatever air reaches the outer surface of the drum does not cool the actual braking surface: the heat has to be conducted through the drum before radiation and convection play their part. Unfortunately, materials commercially available, and desirable on other grounds, are not good conductors. Consequently, the braking surface, with only a fractional portion of its circumference exposed to only a minute air flow, is seriously over-heated to an extent which can even destroy the structure of the metal of the braking surface and, of course, at the same time play havoc with the lining. Moreover, the steep heat gradient through the drum metal tends to cause an unhappy form of drum distortion.

Attempts are made on racing cars to duct air into the drum space, but the amount of air which can be passed through in this way is limited, and much of the actual braking surface of the drum is masked by the lining.

It is in the endeavour first to cool the braking surface itself, and secondly to cool it better, that the disc brake (subject of separate essays) was developed, together with an interesting parallel to it, an American drum type of transmission brake, in which a small arc of the drum is squeezed between an inner and outer brake pad, enjoying cooling conditions closely similar to those of the disc brake.

We seem to be committed to dissipating the energy as heat, and it is most desirable to avoid the use of small friction surfaces which—since they can influence only a small stream of air—can disperse the heat only by attaining an undesirably high temperature. What we would like to have is a large braking surface influencing a large mass of air and thereby having its temperature kept within reasonable limits.

There is a rough parallel in the aircraft engine. To propel the aircraft with a propeller we need a large cross-section of air from the propeller disc, at a comparatively low pressure difference. The piston type of engine, however, develops a high pressure difference over the small area of its pistons, and to convert this to what is needed involves the use of a dozen or more pistons and their connecting rods, a most unstructural-looking crank shaft, a reduction gear, a variable-pitch propeller, and perhaps a 2-speed super-charger for good measure, all of this being contrived to develop a high pressure over a smaller area, and then to change it to a low pressure over a larger area.

Against all this, the jet engine more or less holed out in one!

Are there any such short cuts in braking? What means are available for dissipating energy in a comparatively gentle manner: what has been done in that direction? We hope to give some of the answers later.

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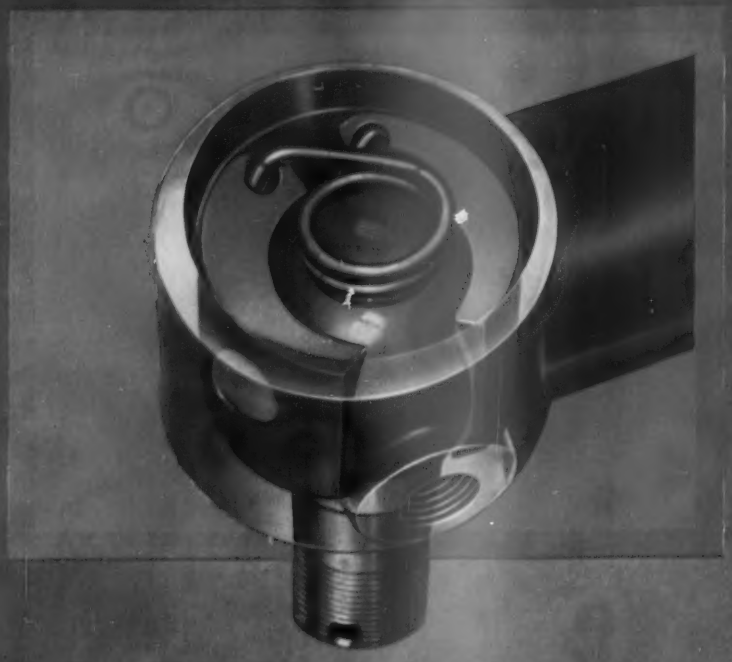
ECCENTRIC TYPE BALL JOINT, SIZE 1½ INCH

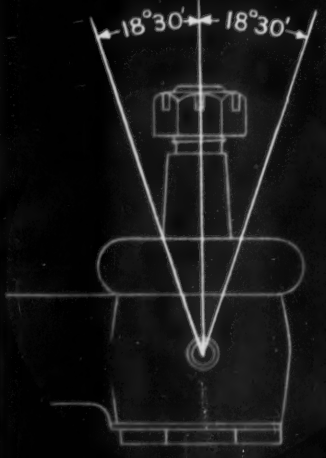


The Thompson eccentric-type of tie-rod is made in a range of sizes, 1″, 1¼″, 1½″, and 1¾″, to suit vehicles having front axle weights ranging from 4,000 lb. to 8,500 lb.

The illustration above shows the well-proved construction, the diagram in the margin shows the angular movement attainable. The tie-rods have right- and left-hand adjustment with lock-nuts.

Drag-links are also available with the eccentric-type of self-adjuster.

A comprehensive catalogue gives full particulars of the eccentric and dual types of Thompson tie-rods and drag-links, including some with a high degree of angular movement.



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Shell Rotella Oil

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The Greeks had no word for it

Great epics have been written—said the Managing Director—
about the glory that was Greece and so on and so forth but,
for myself, I regard the Ancient Greeks as rather Small Beer.
As every schoolboy knows, they sat outside the City of Troy
for ten solid years arguing and quarrelling before they thought up
the rather childish idea of getting inside
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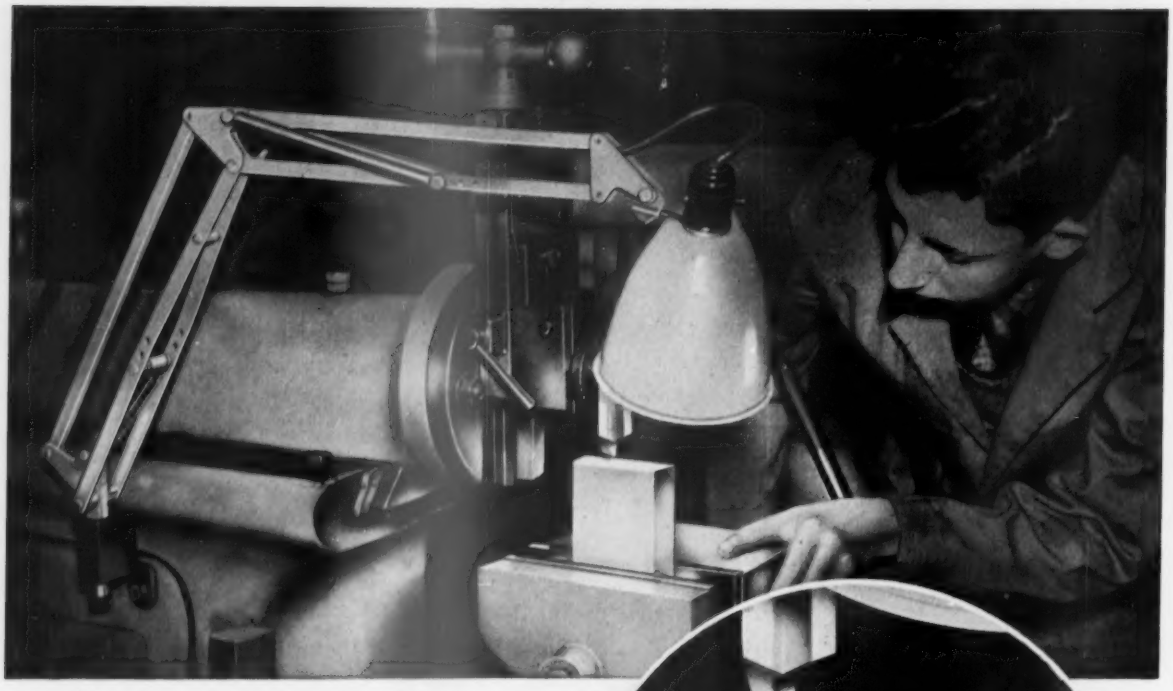
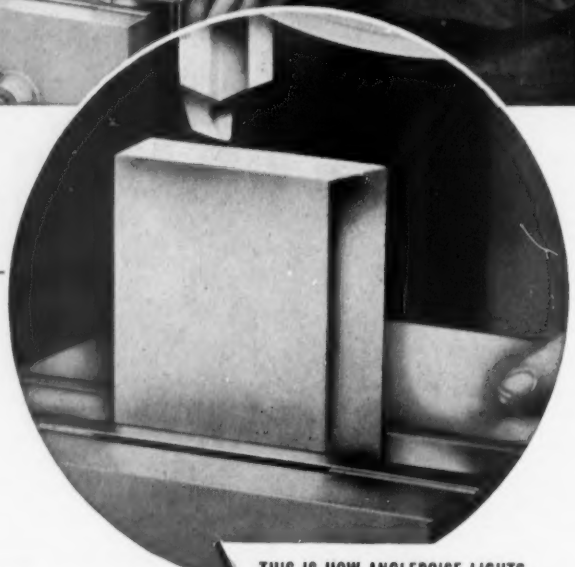


Down a little!

Still nearer!

Right on the job!



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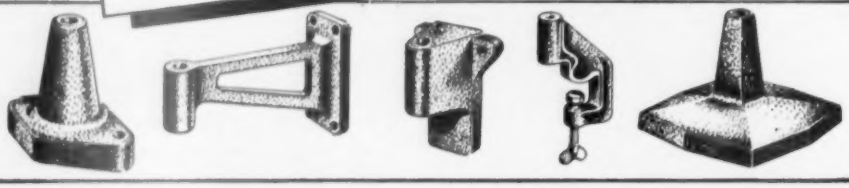

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the men who fit them

the men who use them

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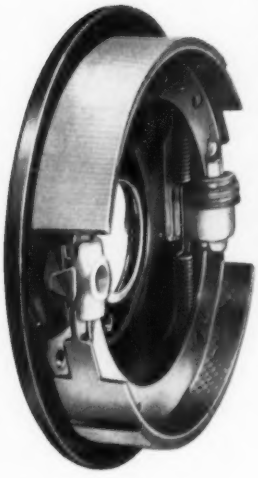

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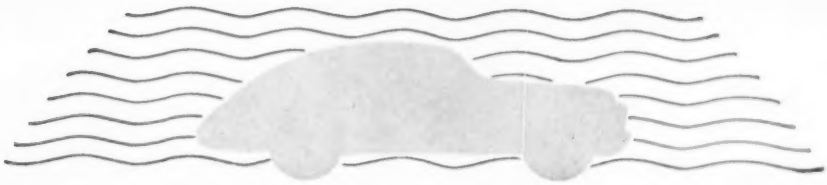
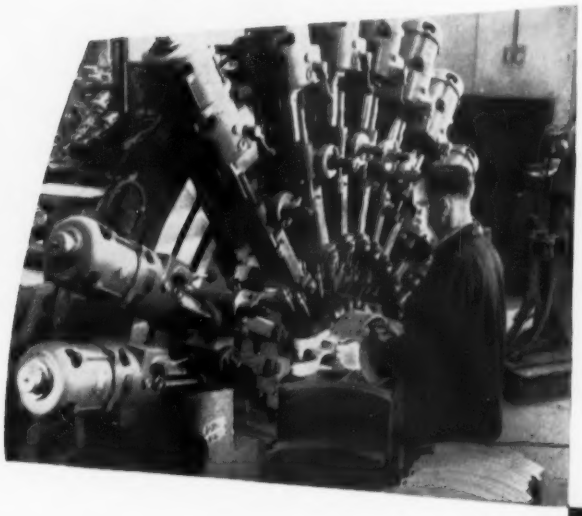


New styling brings new problems



As the stylists create new body designs, cutting down wind resistance with slab-sides and covered wheels, they increase the need for Brake Linings with the highest possible performance. As the engineer knows, streamlining makes a car harder to stop, besides partially cutting off the flow of cooling air round the brake drums. This, combined with faster speeds, means higher and higher temperatures for Brake Linings to withstand.

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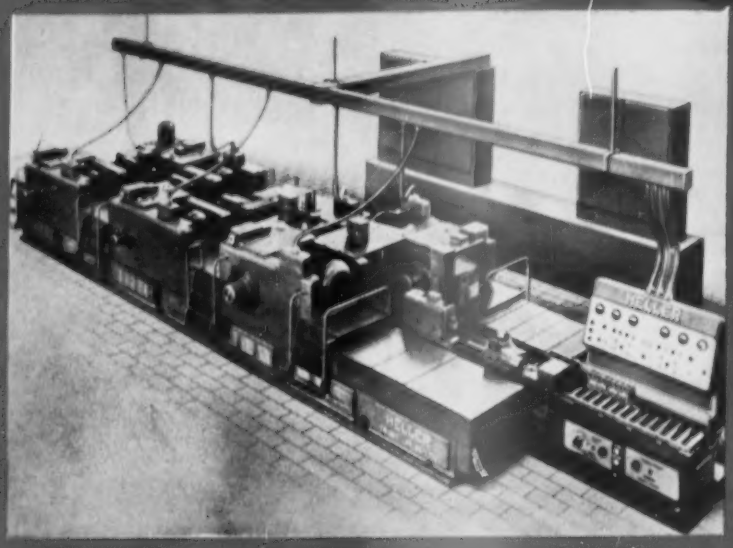
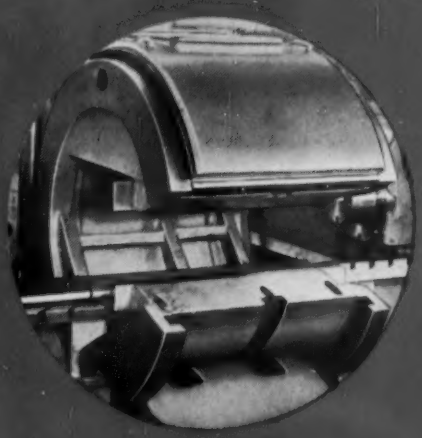
A Heller Transfer Line for 4-cylinder engine blocks.

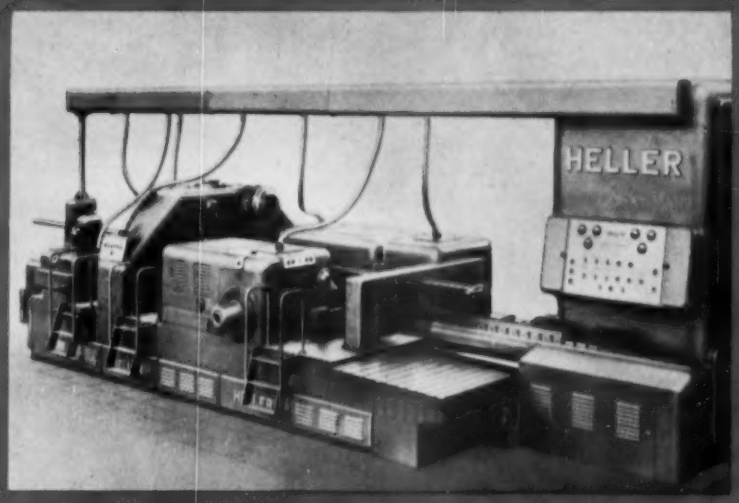


Cylinder Head Line
(4 cylinders)

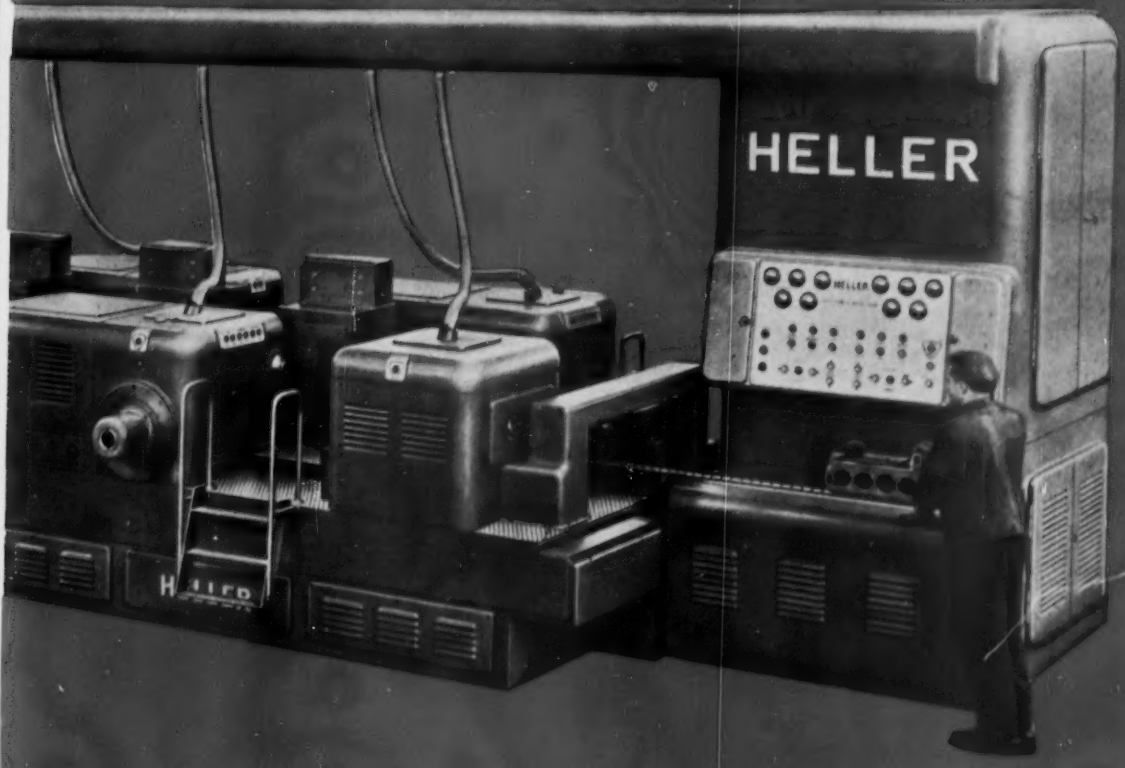
Milling side and front faces, joint face, and combustion chambers. Drill/ream location holes for following operations.



TURNOVER STATION



Cylinder Head Line
(4—6 cylinders)
Milling side and front faces, and drilling locations for following operations.



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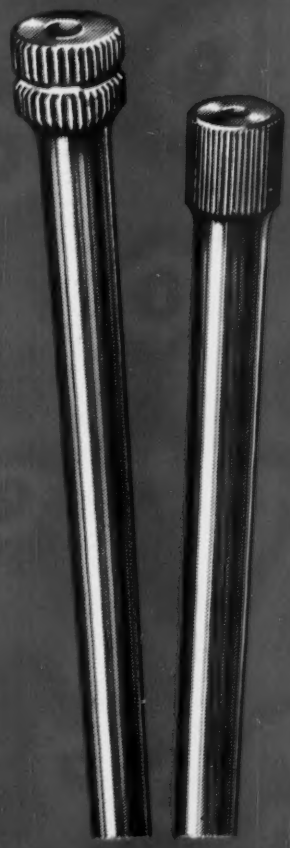

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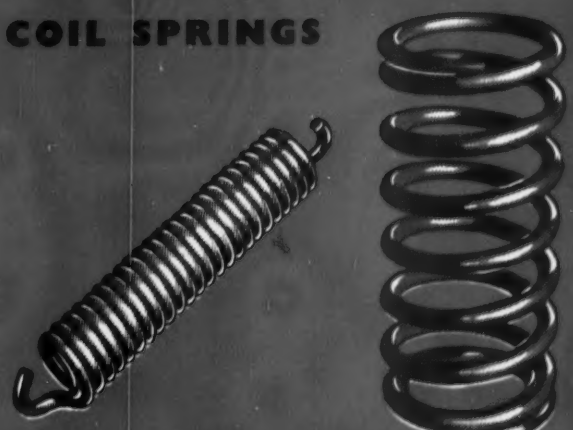

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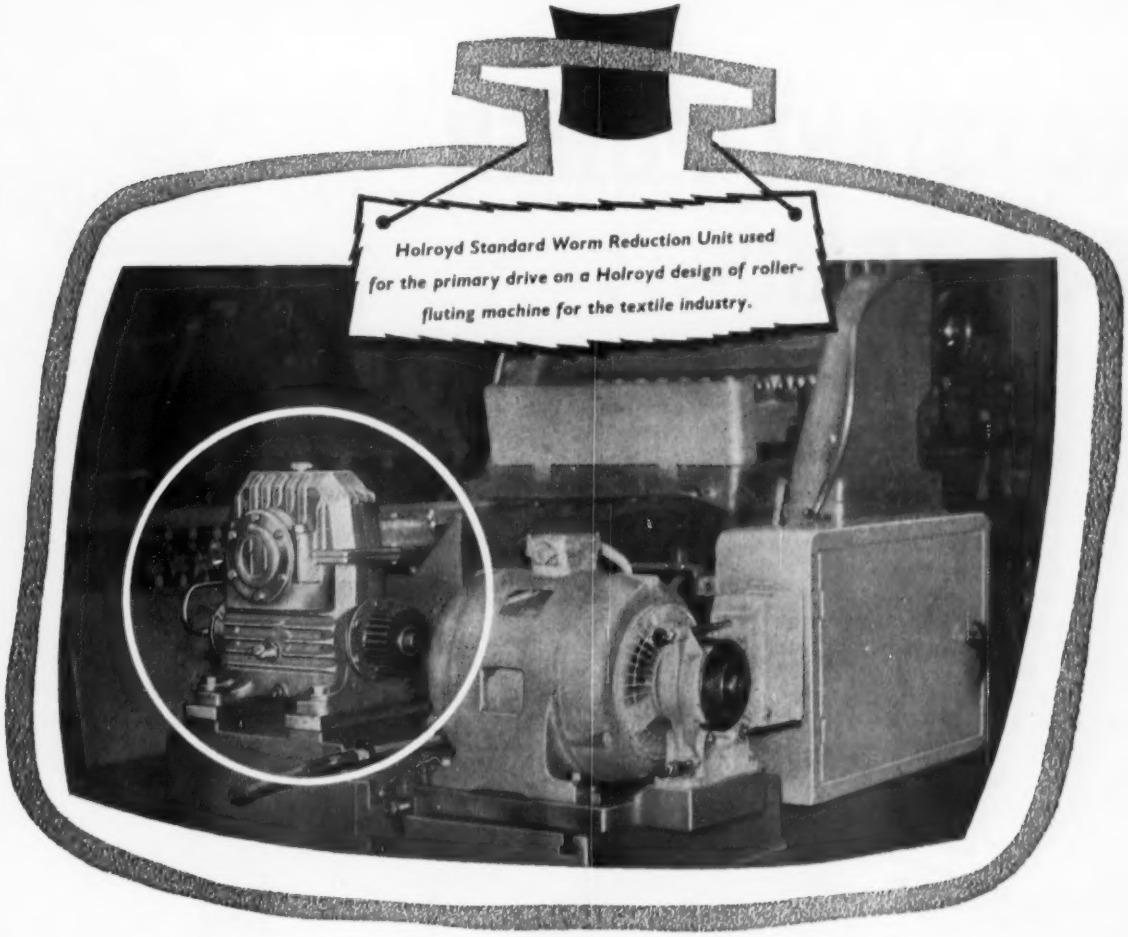
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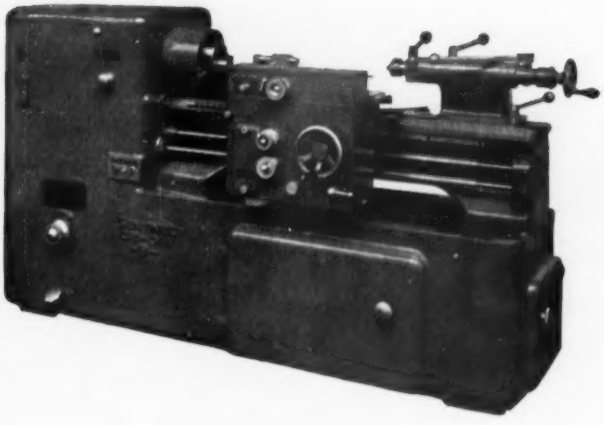

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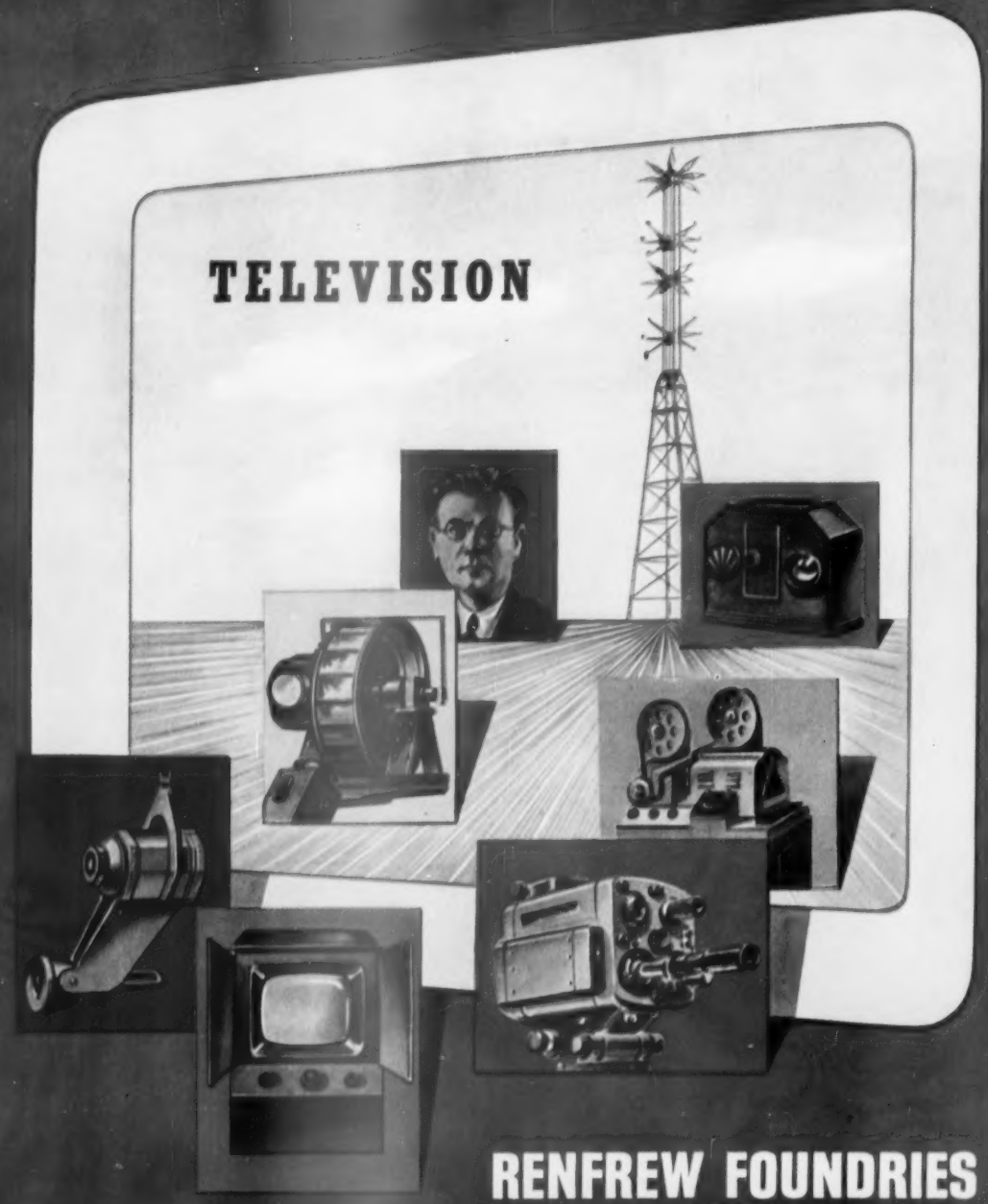

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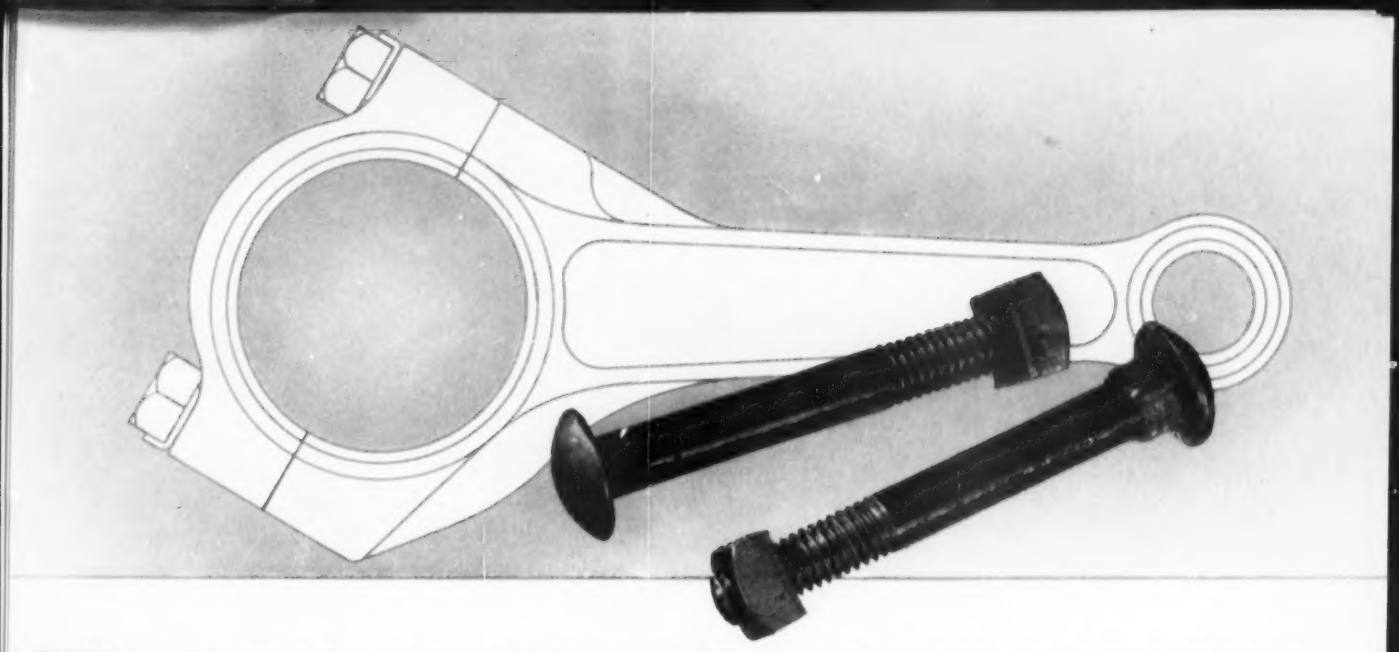

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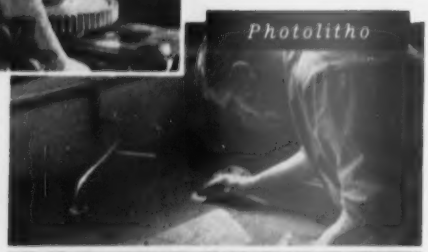

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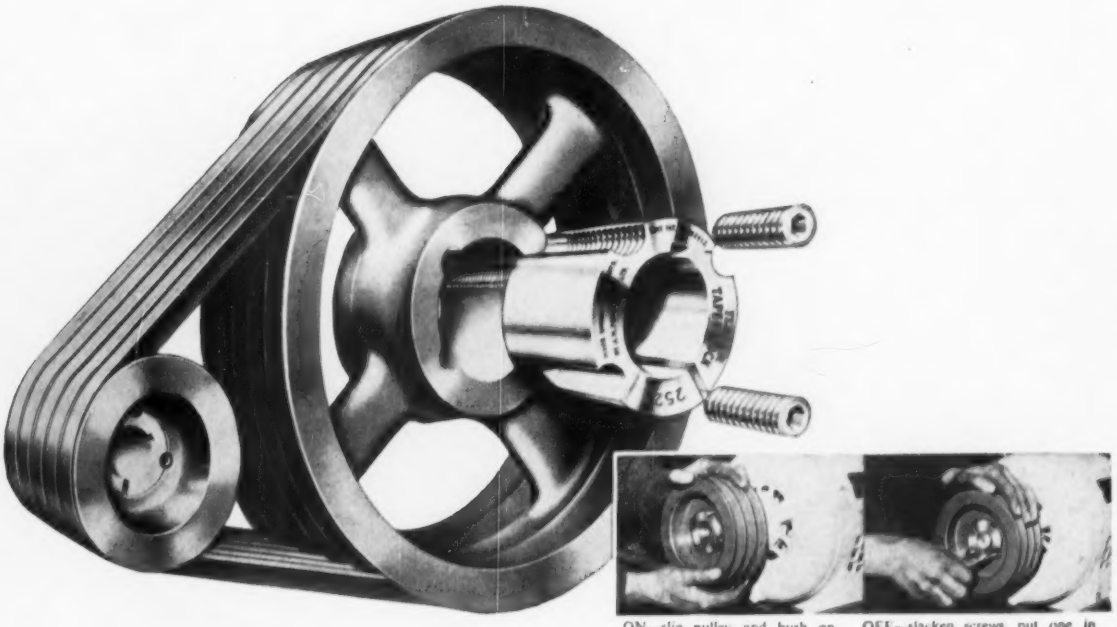

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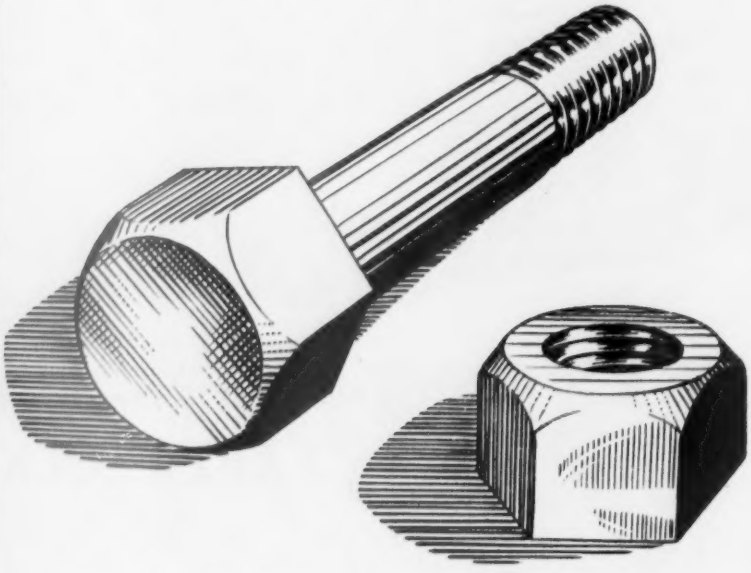

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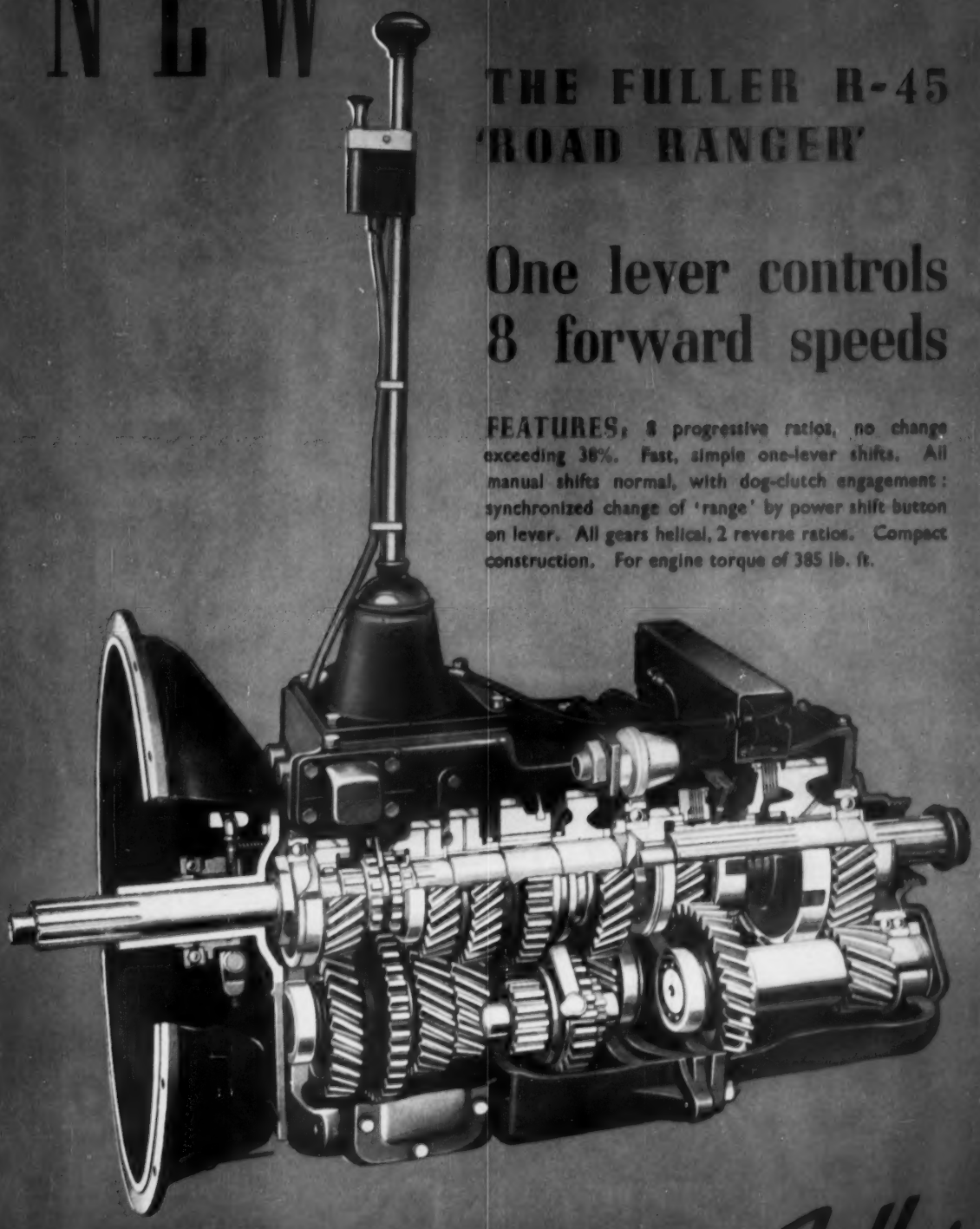

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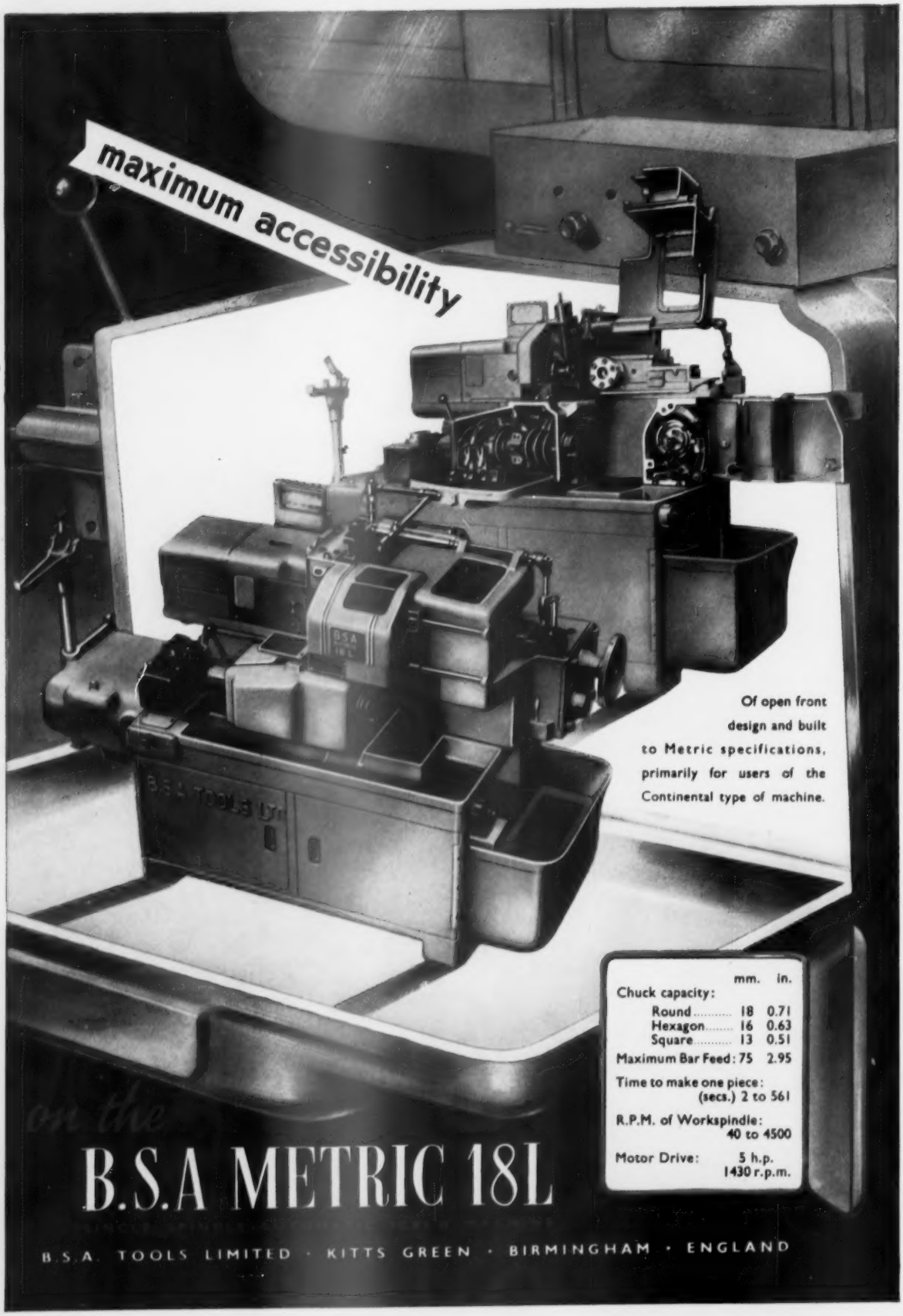
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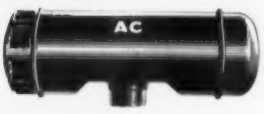

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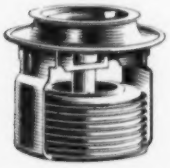

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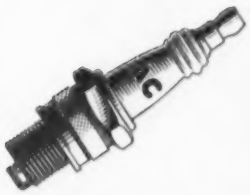

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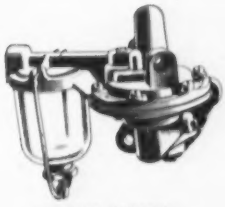

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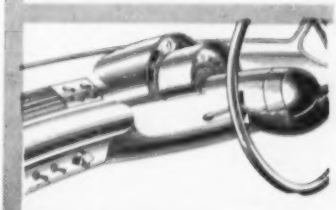

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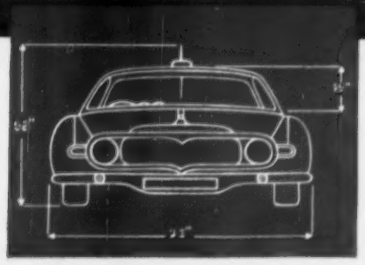

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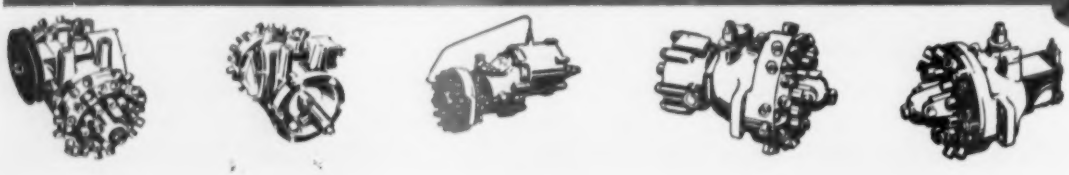

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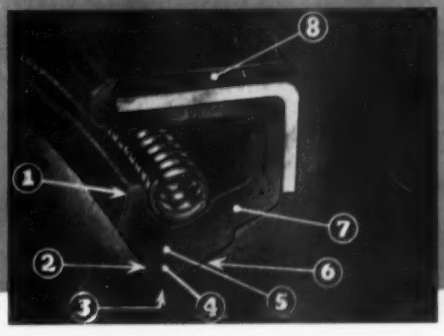

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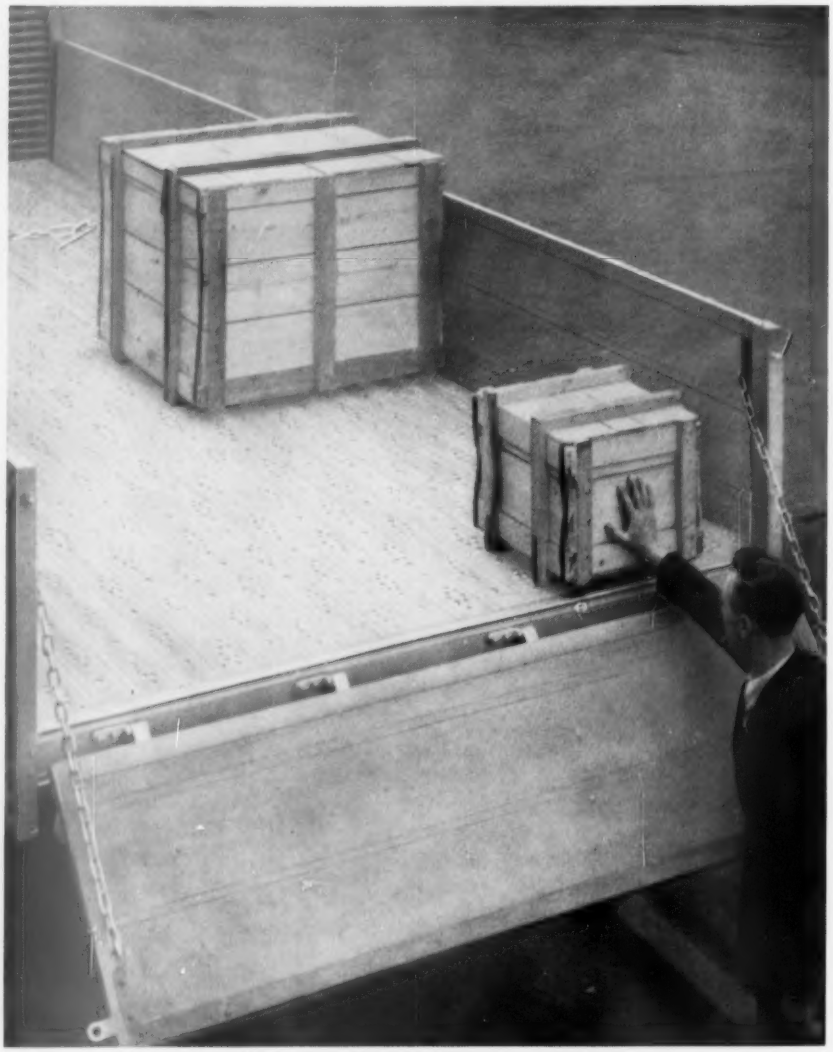

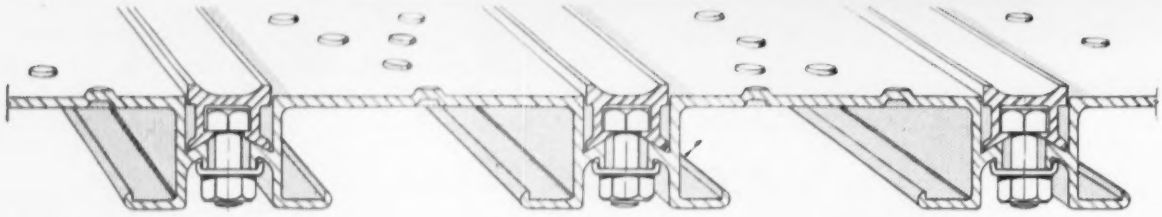

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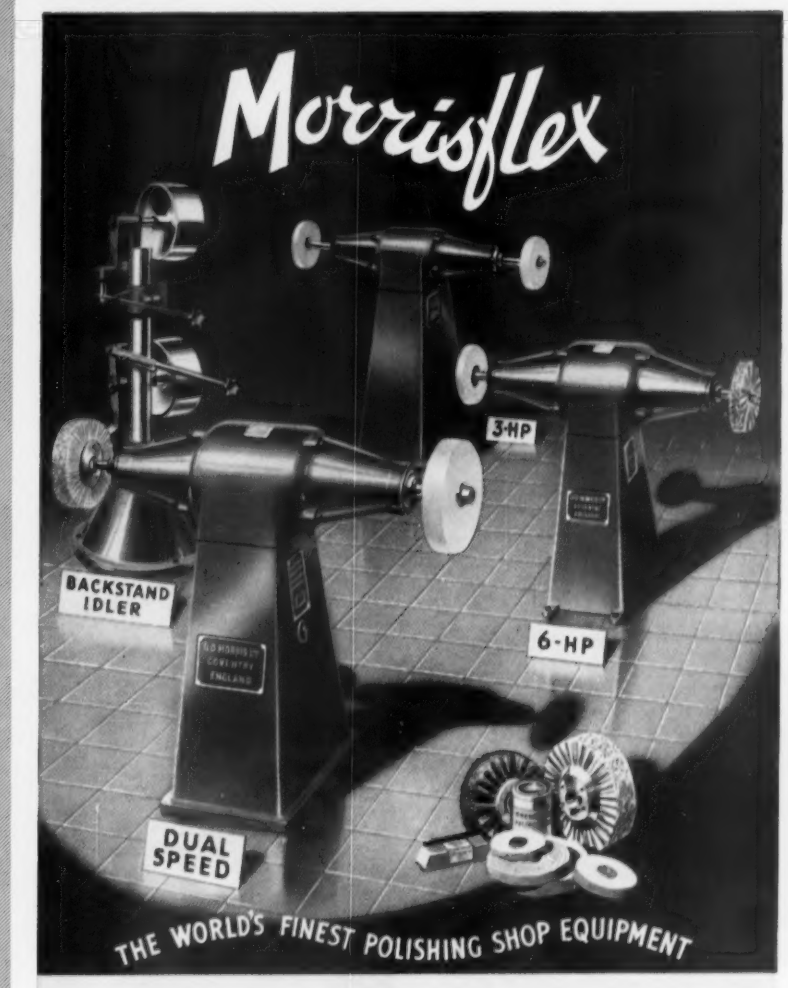

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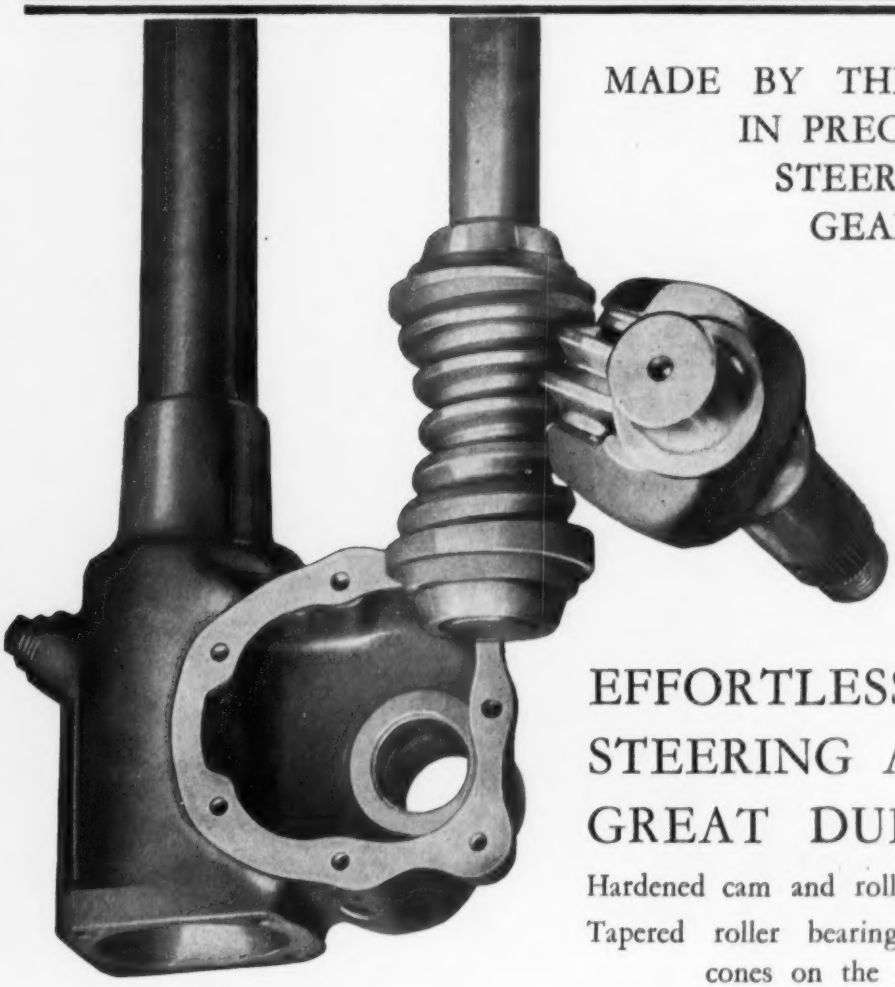

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EFFORTLESS
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Hardened cam and roller.

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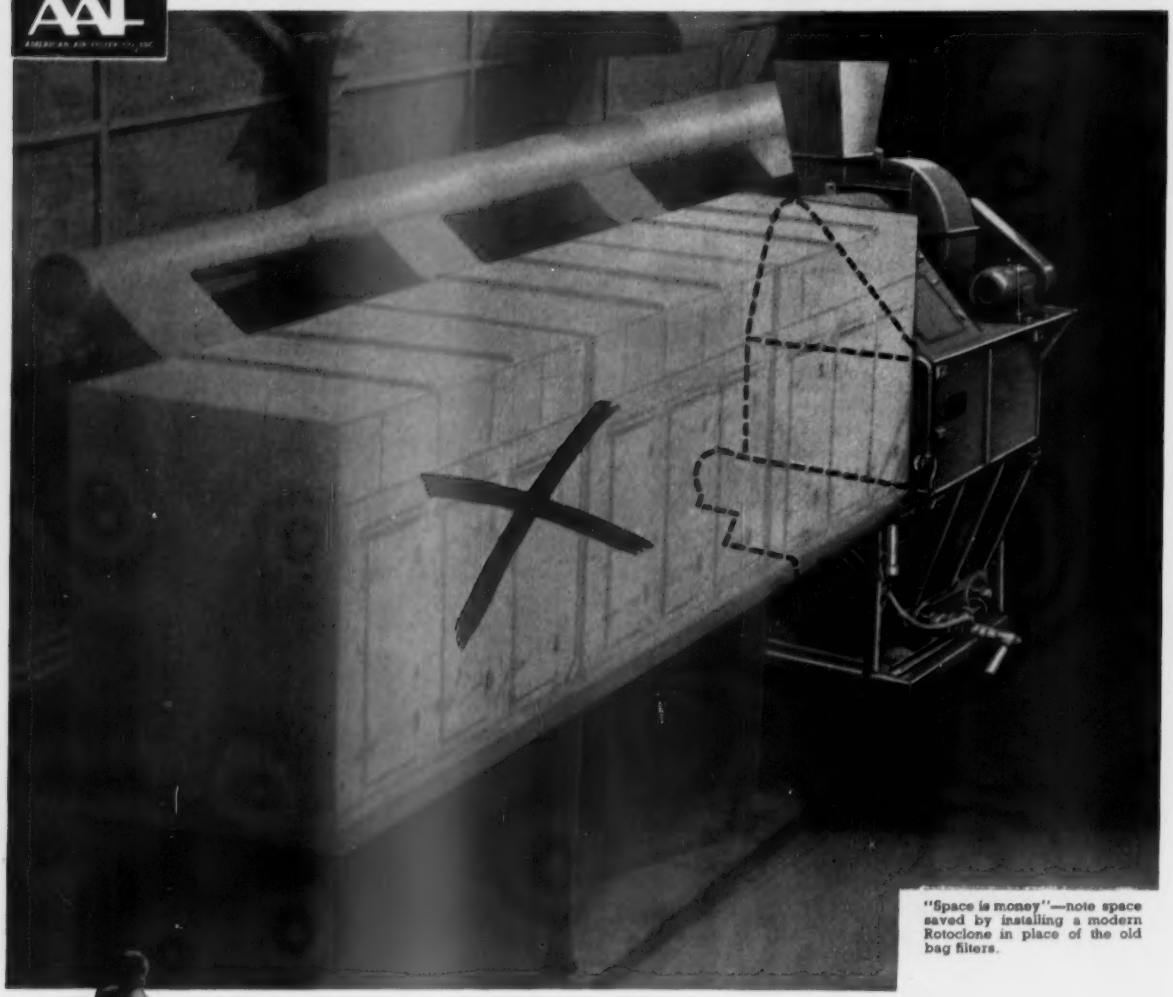

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The Standard Motor Co. Ltd. called us in to provide better control of dust produced by their carburising processes. The bag filter plant was not very efficient, fires were common and maintenance expensive.

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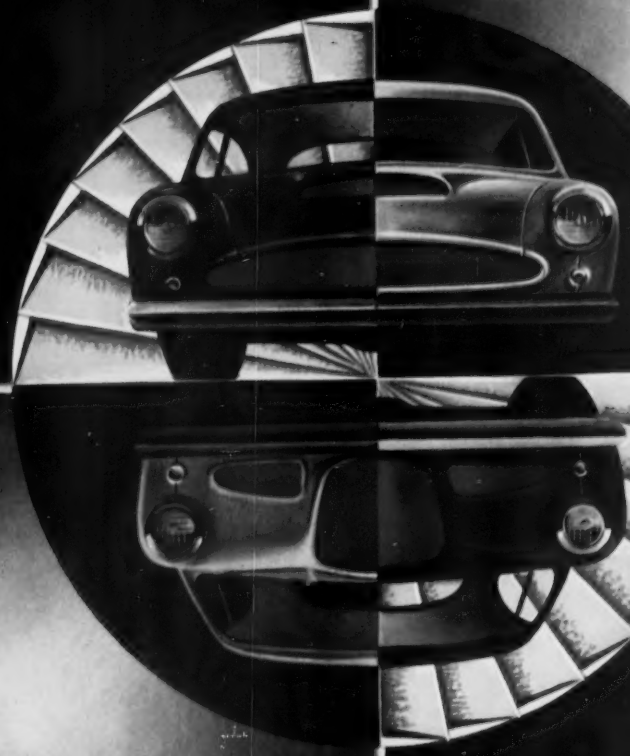
At the windtunnel stage...



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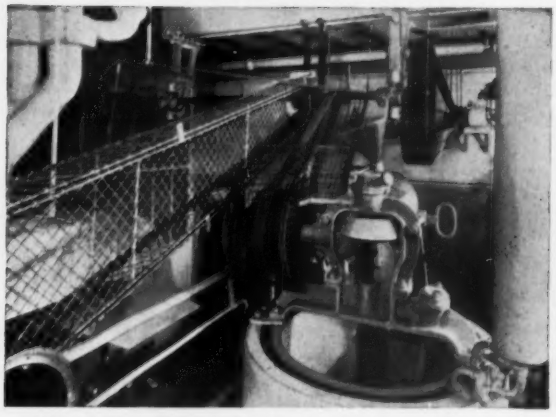
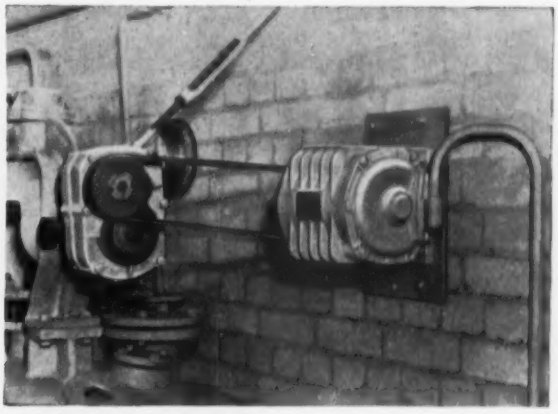


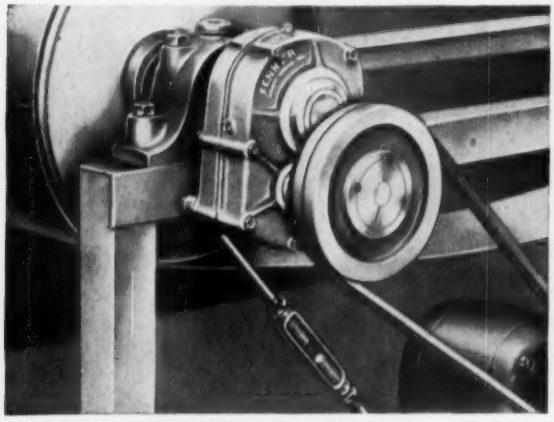
THE OLD METHOD.

A nationally famous firm of manufacturing chemists had the problem of driving chemical mixers at 60 r.p.m. A base mounted gear box was impractical and a cumbersome and expensive double reduction overhead drive had to be used.



THE NEW METHOD.

A Torque-Arm shaft mounted speed reducer was installed on top of the mixer driven through a Taper-Lock V-Drive by a wall mounted motor. Advantages: clean safer drive, economy in space, simplified maintenance, more useful power transmitted.



TORQUE-ARM CAN HELP YOU TOO!—

Space limitations no longer prevent you installing a speed reducer. The Fenner Torque-Arm Reducer mounts direct on the driven shaft and can be driven through any V-Belt Drive. It delivers up to 97% of power to output shaft. No motor base or slide rails are required, no flexible couplings needed. It is suitable for the majority of slow speed drives.

TECHNICAL LITERATURE IS AVAILABLE.

Literature giving all the facts about Fenner Torque-Arm Speed Reducers is available . . . send for your copy TODAY. Fenner Technical Advisory Service will be glad to consider your Speed Reduction problems and advise on the suitable application of Torque-Arm Speed Reducers.

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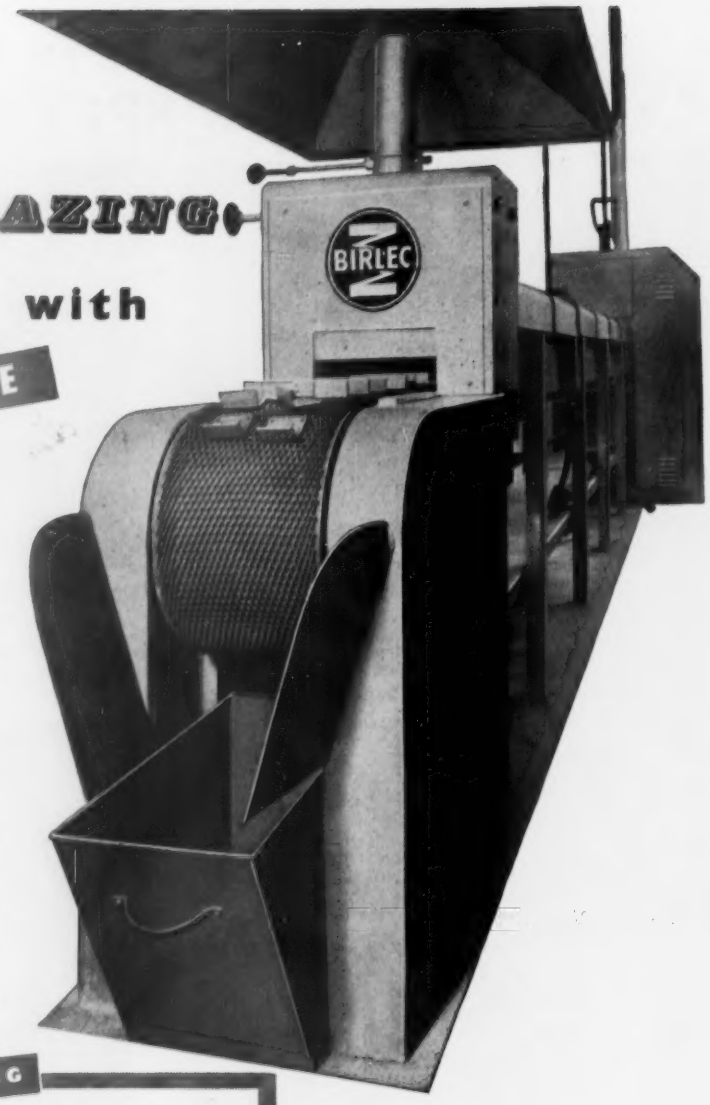
continuous COPPER BRAZING FURNACES with REMOVABLE elements



Birlec Limited can now offer continuous copper brazing furnaces with removable non-metallic elements as standard equipment. Extensive production trials have taken place and the following advantages proved:—

- ★ ***Element replacement is easy and can take place, if necessary, while the furnace is in operation.***
- ★ ***Element replacement does not involve rebricking, and expensive downtime is thus reduced.***
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For brazing a small part to a large article, induction heating equipment is the answer; localised heat means no wasted heat and a "machine tool" approach to equipment design makes the process ideal for quantity-production methods.

Illustration left: A standard 5kW unit, for brazing carbide tool tips; photograph by courtesy of EDIBRAC LTD., Broadheath, Cheshire, manufacturers of Tungsten Carbide products.

Designs are completed for standard 6", 8" and 12" furnaces; may we send details? We should also be pleased to arrange a visit to our Heat Treatment Division, near the main works in Tyburn Road, where test pieces can be brazed in a furnace of this type.

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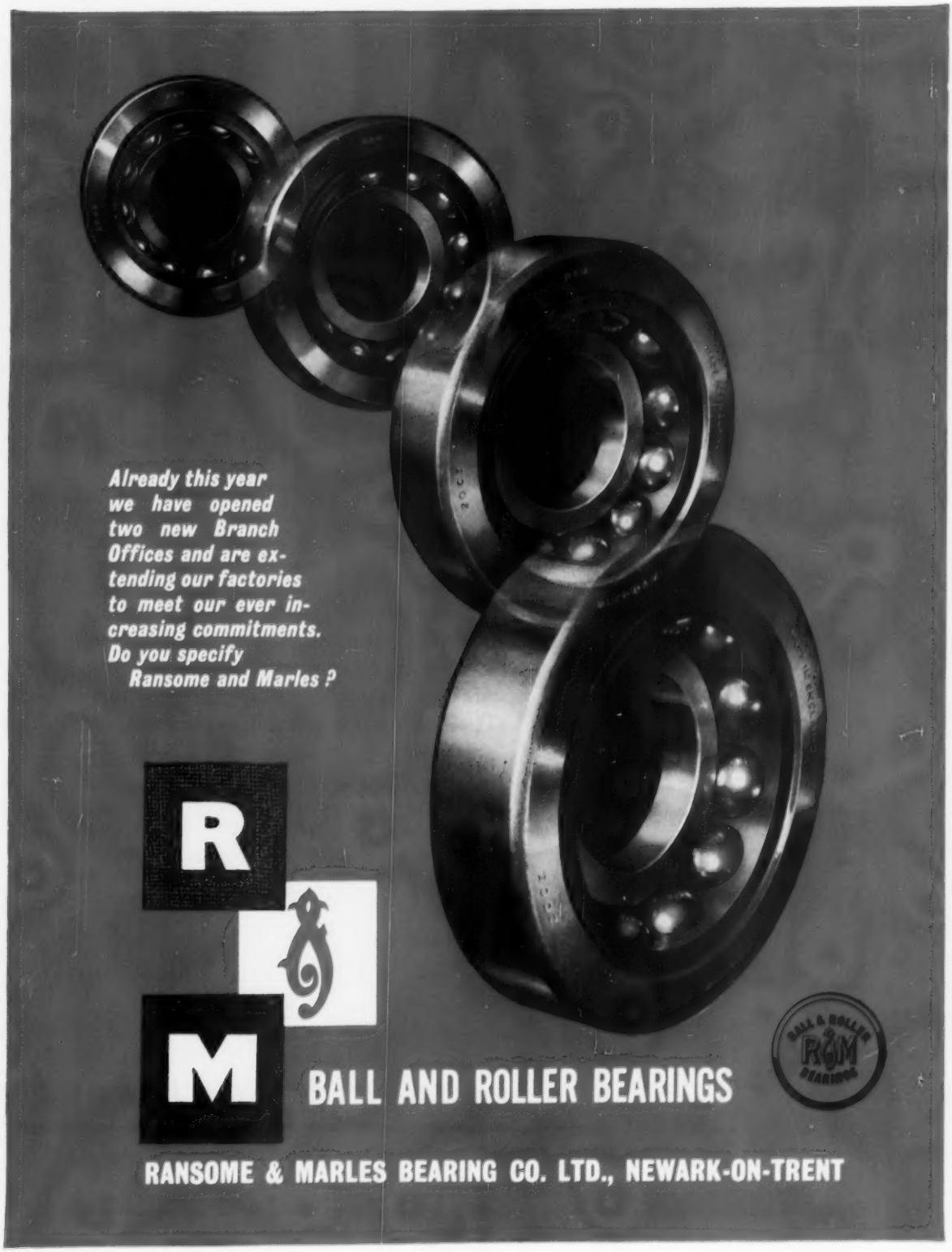
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TOOLROOM FAVOURITES

Illustration by courtesy of Siemens Brothers & Co. Ltd.

KE 970 This type of 2% Carbon 14% Chrome Steel is recommended for the highest duty work possessing the desired properties of deep hardening, a high resistance to abrasion together with the minimum amount of distortion in hardening. It also has the ability to withstand drawing in tempering after hardening over a much wider range of temperature than is normally permissible with standard alloy tool steel types. We also supply K. E. 961 1½% Carbon 14% Chrome Steel in cases where increased toughness is desired at the expense of a slight reduction in hardness.

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All K.E. Tool Steels are supplied in the annealed condition, carefully controlled both with regard to temperature and atmosphere to render them most suitable for subsequent tool room manipulation.

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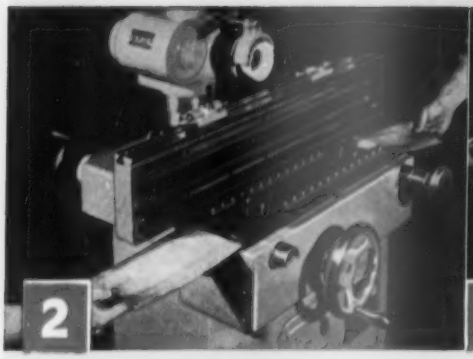
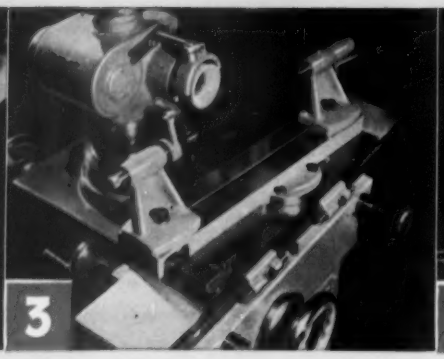
ANOTHER NEW CINCINNATI

1

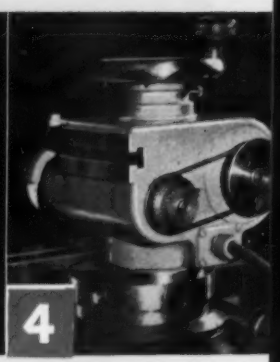
Seated or standing the operator can get in close to the work, in both front and rear positions.



Super-sensitive anti-friction table slide (curtained against grit) gives smooth traverse and minimizes fatigue.



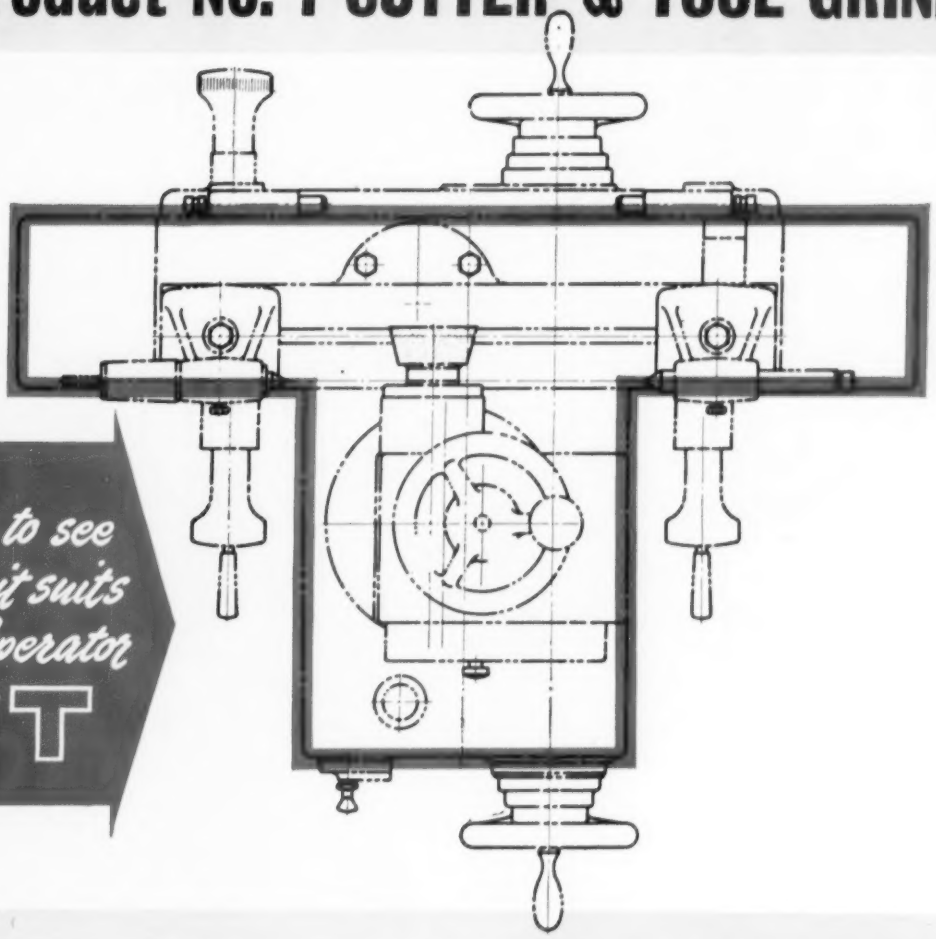
Swivel Table 'Tange Bar' device takes the 'hit or miss' out of taper grinding; reduces set-up time.



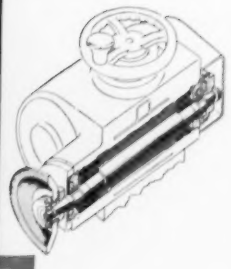
Reversible 2-speed motor, i tegral with the wheelhea gives immediate change grinding wheel direction.

CINCINNATI MILLING MAC

product No. 1 CUTTER & TOOL GRINDER

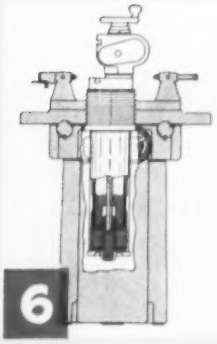


Easy to see why it suits the Operator



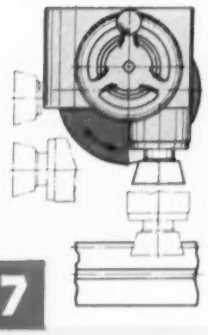
5

Grinding wheel spindle lubricated for life.



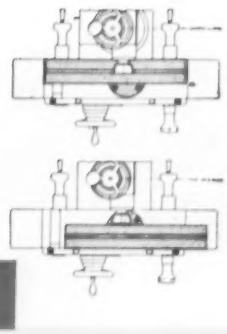
6

Wheelhead pile (sealed against grit) is easily adjusted to correct height, by handwheel at top of wheelhead unit.



7

Eccentric 360° wheelhead swivel increases cross range of wheelhead.



8

Cross range of machine still further increased by 180° swivel of table.

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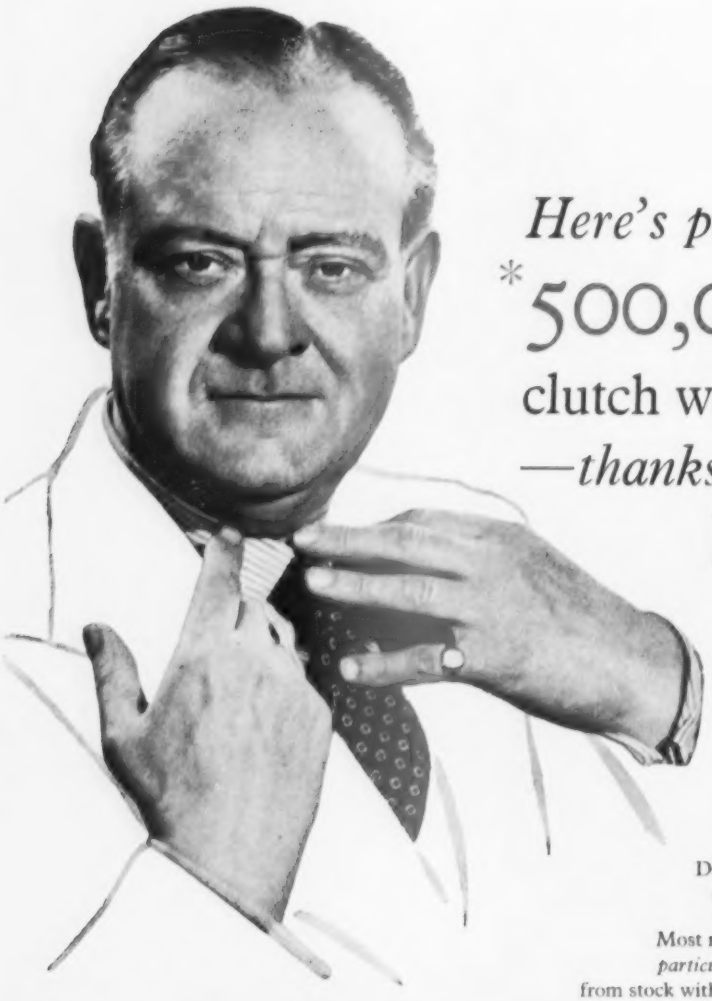

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clutch wear practically nil

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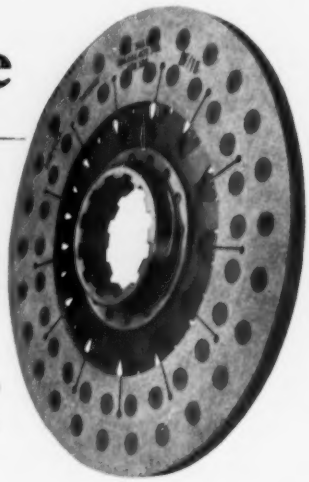

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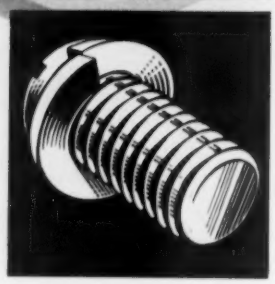

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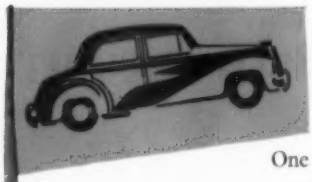

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One of the many industrial applications of Texolex laminated mouldings is in the motor industry where extensive use is made of this material for cam gears. Some of the largest motor manufacturing organisations have found in Texolex many of the qualities of the ideal material, offering silence in operation, lightness in weight, high mechanical strength coupled with resistance to wear and corrosion.

TEXOLEX IN THE AUTOMOBILE INDUSTRY

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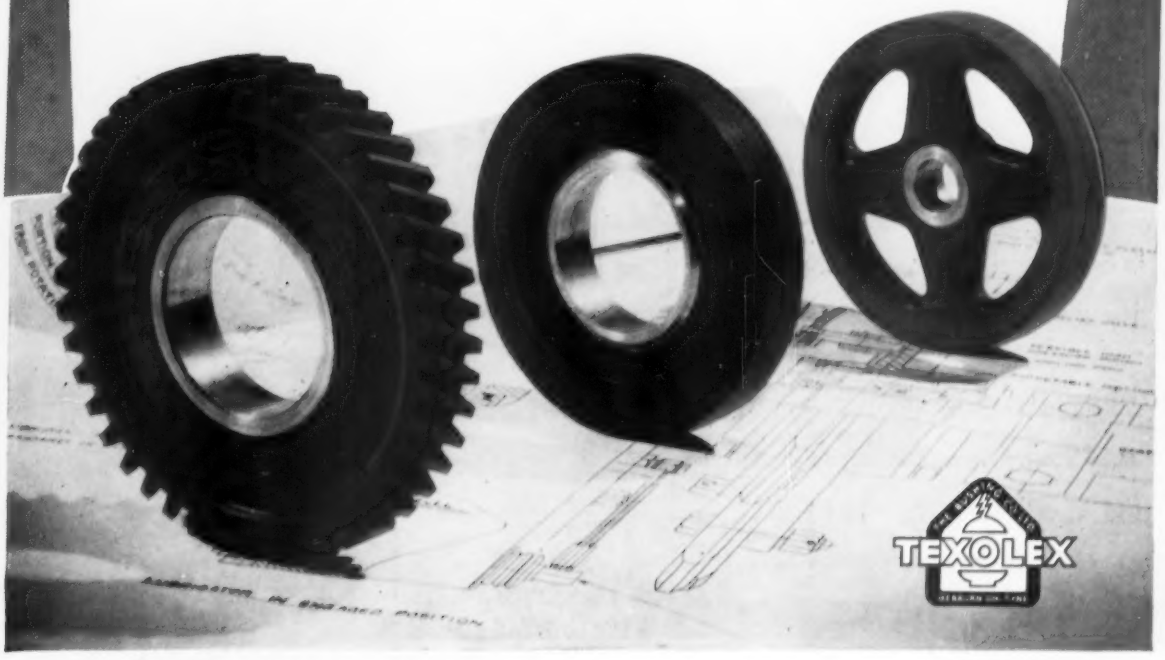

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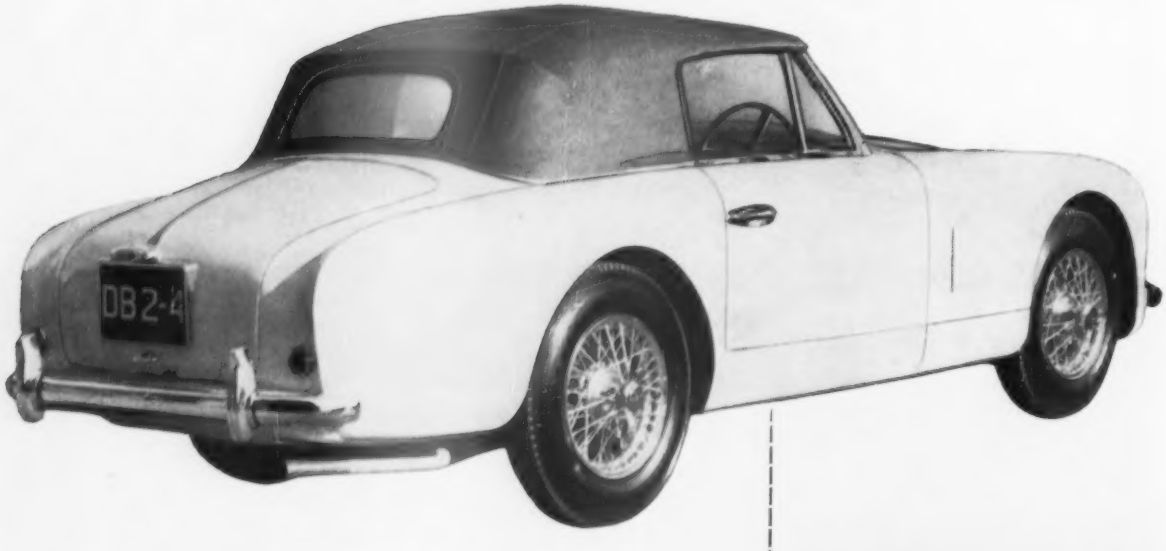
In the Aston Martin...

AS IN ALMOST EVERY BRITISH COUPÉ



...you'll see VYBAK Flexible Clear Sheet

This Aston Martin, like almost every British coupé, has a rear window of VYBAK Flexible Clear Sheet because it means clearer, wider vision. The large rear window is possible because VYBAK Flexible Clear Sheet folds or rolls with the hood, without cracking, crazing or marking in any way. It is tough, long lasting, resistant to warping and discoloration, with a high polish to match the splendid finish of the car. VYBAK Flexible Clear Sheet, which is also used for sports car side-screens, is obtainable in several thicknesses. Please write for samples and further details.

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*Vybak Products include: **Vybak** rigid and flexible pvc compounds for moulding and extrusion; **Vybak** calendered sheet; **Vybak** rigid and flexible pressed sheet—coloured and transparent; **Vybak** PVC-A Copolymer resins.*

DAVID BROWN ASTON MARTIN

VYBAK REGD.

Flexible Clear Sheet

Formula for STEEL

Most properties of materials have some concrete meaning even to the non-technical mind but values for permanent magnets are in abstruse terms, which can be explained only by graphs or mathematical formulae.

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Nevertheless the properties are real and the outstanding extent to which modern-efficiency magnet alloys have been developed can be universally appreciated in the strength of their magnetic "pull".

Illustrated are some of the items of equipment used in determining magnetic properties.

This is the tenth in a series of illustrations of highly specialised equipment devised to control the production and testing of special steels by William Jessop & Sons Ltd.

WILLIAM JESSOP & SONS LTD

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STEELMAKERS, SHEFFIELD

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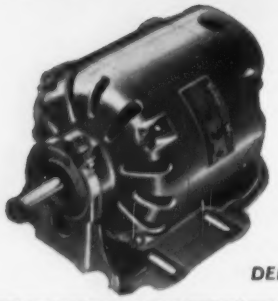
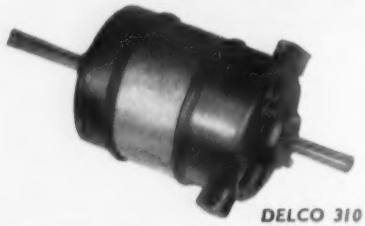
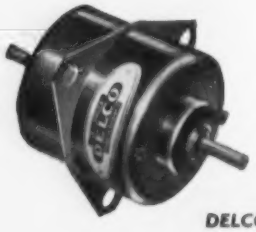
DELCO motors



DELCO 6½" TYPE



DELCO 310 TYPE



DELCO 258 TYPE
with flange mounting

Before you start work on your plans for Automobile applications which call for compact, high-efficiency electric motors . . consult Delco engineers. The Delco range includes motors to meet most modern requirements—from car heaters to axle gear shifts. These versatile motors are so designed as to be easily adapted to suit your individual needs.

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On June 15th 1215—in face of a vast assembly amongst which he had hardly a single friend—King John sealed the famous Magna Carta at Runnymede, close to Windsor. A long document of 63 clauses, some are but trifling concessions to individuals whilst others are of primary importance in the constitutional history of England. Four copies of Magna Carta sealed with the great seal of King John are in existence today. Two are in the British Museum, the others belong to the cathedrals of Lincoln and Salisbury.

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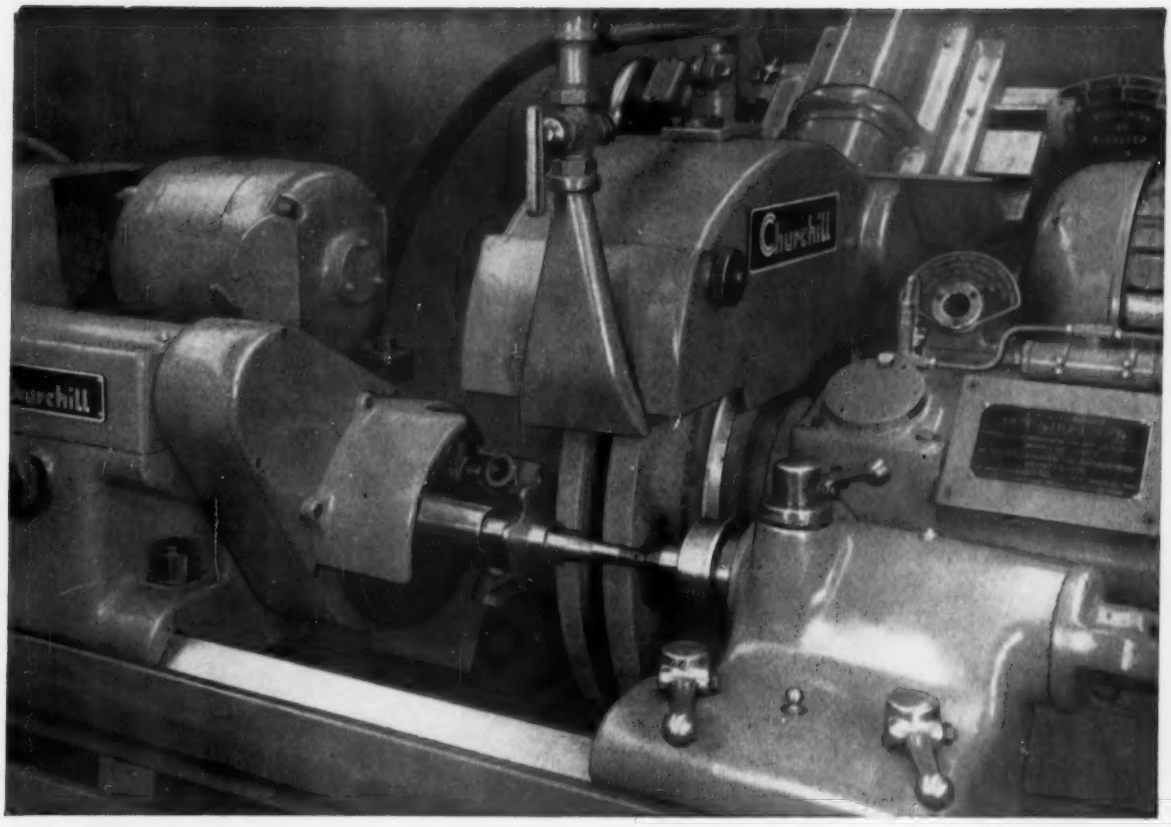
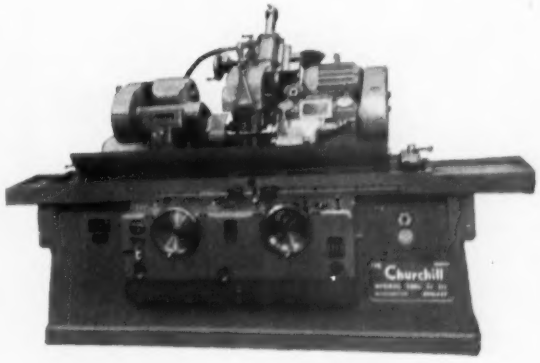


Churchill

THE CHURCHILL Model 'BW' 10" swing Plain Grinding Machine has a reputation for accuracy and high output. The machine shown here is equipped with twin grinding wheels for grinding two diameters simultaneously. The wheel forming device is mounted permanently on the back of the wheelhead and enables the wheels to be trued in correct relationship to the finished work diameters.

The 'BW' Machine can be supplied as a non-automatic or fully automatic Plain Grinder.



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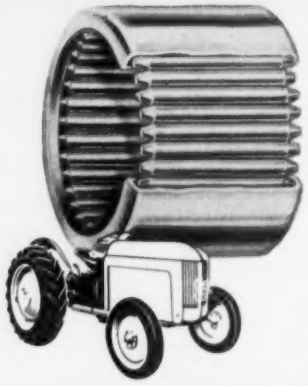
Now available from our English factory.



TORRINGTON NEEDLE BEARINGS are used extensively in British-made Tractors. Outstanding successes include clutch, gear-box, gear-pump and power take-off applications. There are also applications in auxiliary Tractor equipment, such as ploughs, coulters, rakes, elevators, etc.

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Equivalent and interchangeable with bearings of American type and manufacture.

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ROLLER BEARINGS

The Max-Load illustrated above has a single lipped inner race, an outer race with one circlip and one lip, and a pressed steel cage.

In addition Pollard Bearings manufacture Ball, Roller and Thrust Bearings (Cat. BRT/1053). Solid and Flexible Roller Bearings (Cat. RFX). Transmission Equipment and Plummer Blocks (Cat. TR. 27/2). Self-Lube Plummer Blocks (Cat. SL/54). Automobile and Tractor Replacements (Cat. BRM/54). Clutch Withdrawal & Water Pump Spindle Bearings (Cat. CWFP/54).

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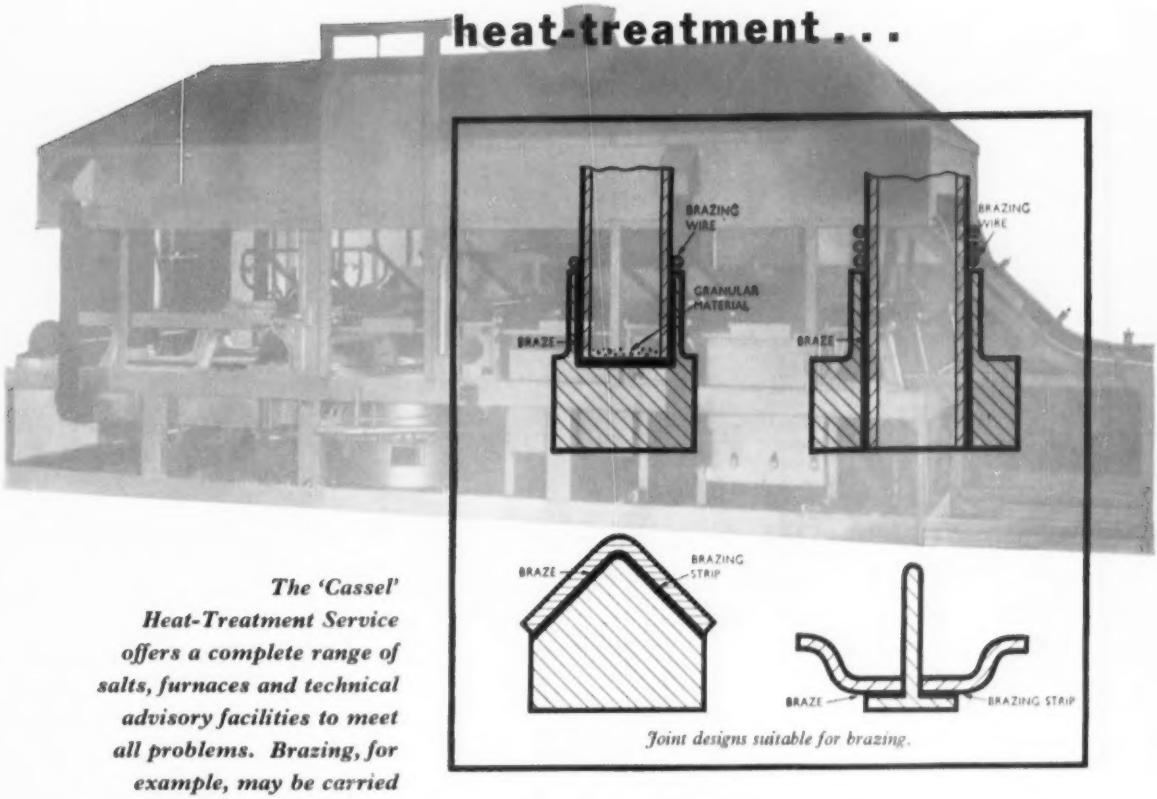
brazing
casehardening
heat-treatment . . .



Joint designs suitable for brazing.

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- ★ **Accurate control of temperature.**
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- ★ **Scale-free finish—less work in finishing operations.**
- ★ **No excess brazing metal on the finished joint.**

. . . consult the
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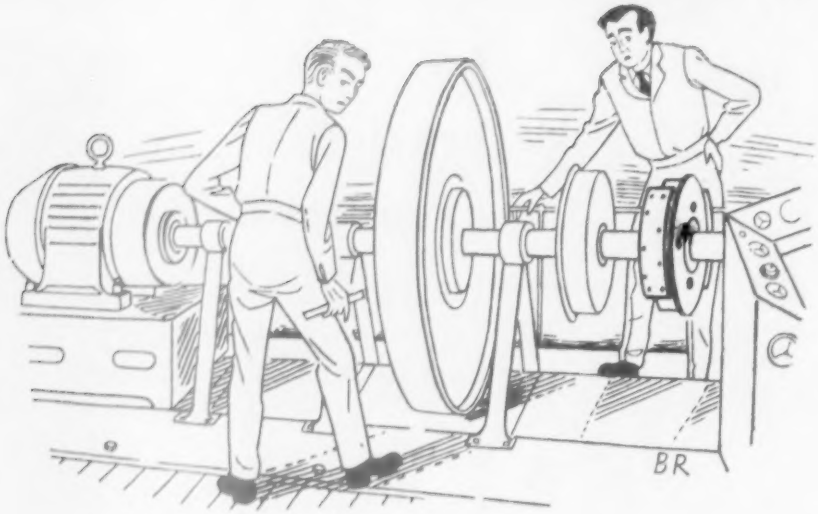

Disappointed, but undaunted,
designer resolves
to battle on.

CAPE

TOUGH BRAKE !

Into our testing department, from time to time, there bursts some member of the CAPASCO research team, bearing in triumph "to-morrow's perfect brake lining". When a short run on the dynamometer reveals that, though it has unquestionably got something, it still falls short of actual perfection, our friend creeps back, disconsolate, to his lair . . . Before many days are out, he, or someone else, will be back again, with some other small but equally solid improvement. Earth-shaking? Hardly; but it is on such small advances that supremacy is built.

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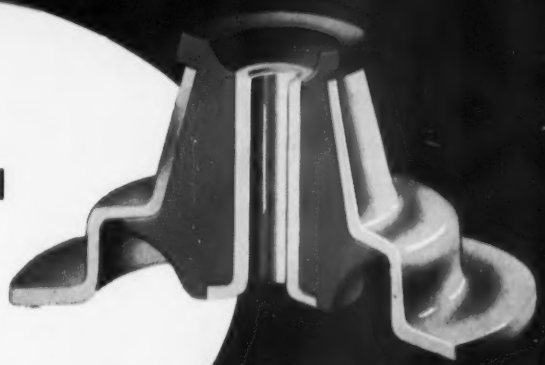
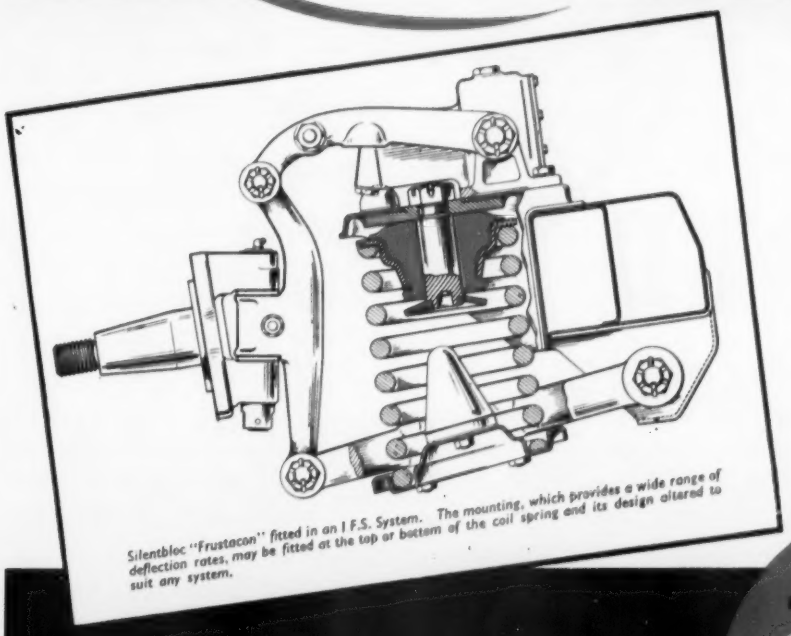
Silentbloc FRUSTACON..

. . . the first scientifically designed flexible mounting fitted to the I.F.S. of a Production Car



The 'Frustacon' mounting fitted to the I.F.S. of the 1952 Rover '75'. Sectioned to show rubber.



Silentbloc "Frustacon" fitted in an I.F.S. System. The mounting, which provides a wide range of deflection rates, may be fitted at the top or bottom of the coil spring and its design altered to suit any system.

To minimise the transmission of road noise to the body by the coil springs, Silentbloc Frustacon mountings have been incorporated in the I.F.S. of the 1952 Rover '75'. This notable step forward in the reduction of noise is another example of co-operation between car manufacturers and Silentbloc Ltd.

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Tel. Crawley 2100

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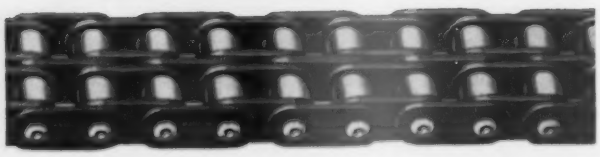

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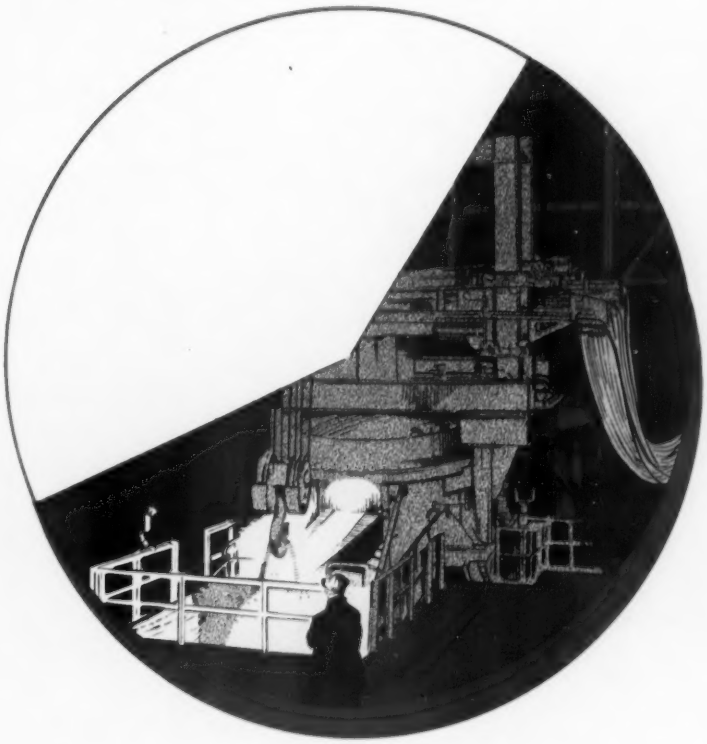
MOLYBDENUM'S PLACE IN INDUSTRY



60%
IN 1954

Molybdenum was used in 60% of the alloy steels made in 1954 in Britain for the construction of components for machinery, automobiles and other products subjected to high stresses.

It needs only a small addition of Molybdenum to improve the physical properties of steel, and it often enables the steelmaker to lower the proportion of scarce elements.

In the United States, Molybdenum is used in 87% of the high-speed tools such as drills, cutters, lathe-tools, hack-saws, etc., which not only give better service, but at the same time cost less. In this field Molybdenum enables the steelmaker to reduce the amount of costly elements, and the present trend towards the greater use of Molybdenum is being accelerated by economic necessity.

In planning to use Molybdenum, steelmakers and users are on safe ground — for in Colorado we have vast Molybdenum resources which should serve the steel industry for the next 300 years: furthermore, the cost of 'Moly' is far more stable than that of most other elements, and has fluctuated to only a fractional extent.

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PRONOUNCED 'MOLLY'

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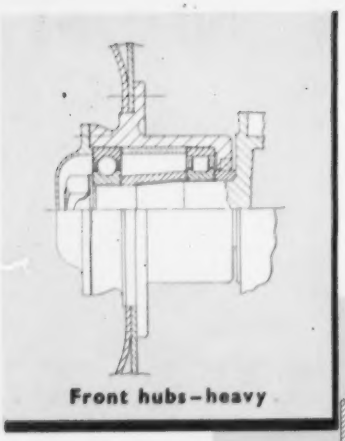
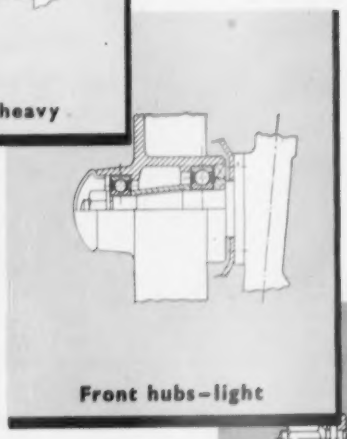
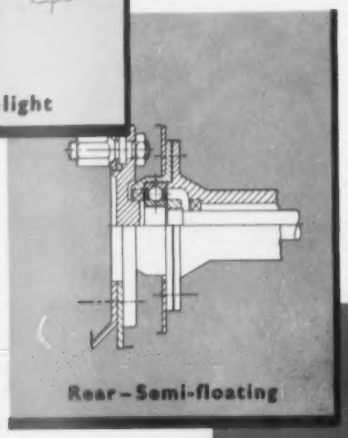
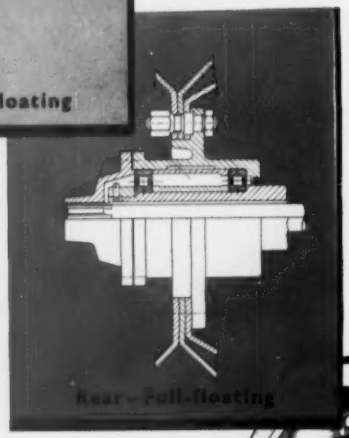

Front hubs–heavy


Front hubs–light


Rear–Semi-floating


Rear–Full-floating

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The use of anti-friction bearings in the hubs of vehicles is universally acclaimed. We can design to suit your requirements or you can choose from our extensive ranges.

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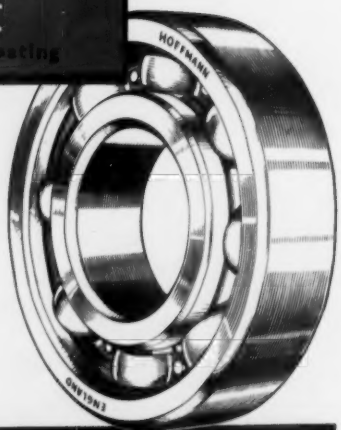

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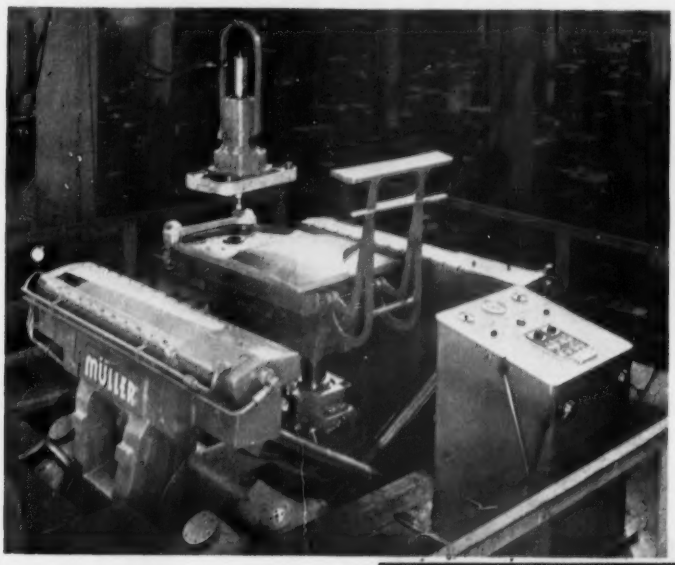

MODEL ZSE 125

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★ *Wrapping motions of the Jaws prevent material waste and enable the material to be brought in under the tool.*

★ *Jaws can be moved outwards or inwards, parallel or at a tangent.*

★ *Centre table can be operated hydraulically and rotated through 90°.*

★ *Completely remote control operation by means of push button and hand lever from a Müller self-contained hydraulic unit.*

★ *Counter draw attachment for drawing recess whilst the job is still on the stretch forming tool.*

★ *Inexpensive wood or concrete dies can be used.*

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Centre Table operated hydraulically and rotates	90°
Hydraulic Clamping Jaws Pressure	100 tons
Counter Drawing Attachment Pressure	50 tons

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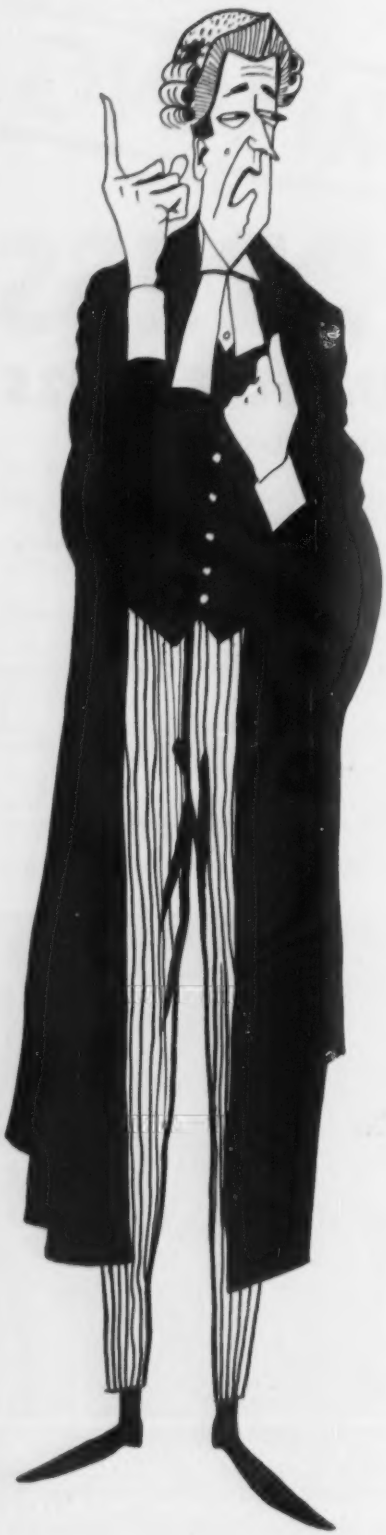

Counsel's Moving Speech

may bring tears to the eyes of the jury—but something more than fine words and flowery phrases are needed when you are selling to the Motor Industry—which is what we've been doing for close on fifty years. We started up our works in Coventry right in the heart of the new industry when the wheels first began to turn. We have grown up with it—and in a world where many have gone to the wall we are proud to have survived and even flourished in a modest way. Which proves that what we make and supply to the car firms must be pretty good—such things as Trim Assemblies, Seats and Squabs, Cushions, Hoods, Carpets, Screens, Tilt Covers for lorries and W.D. vehicles, tractor covers and so on. We have also developed a plastic extrusion and moulding side to the business—if you want anything with knobs on! Although we are quite a small "family" concern with a payroll of some 150 people, we are proud to have some of the biggest names in the Trade on our books—as customers. This doesn't mean we've no time for the smaller enquiry—just try us.

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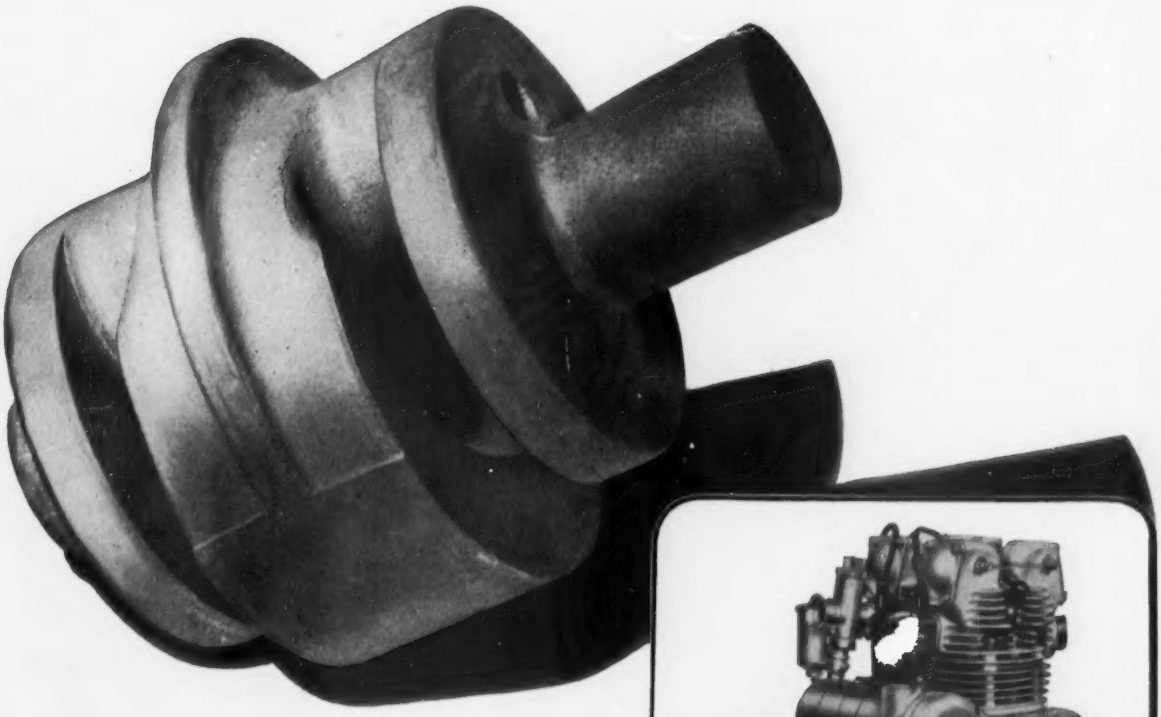

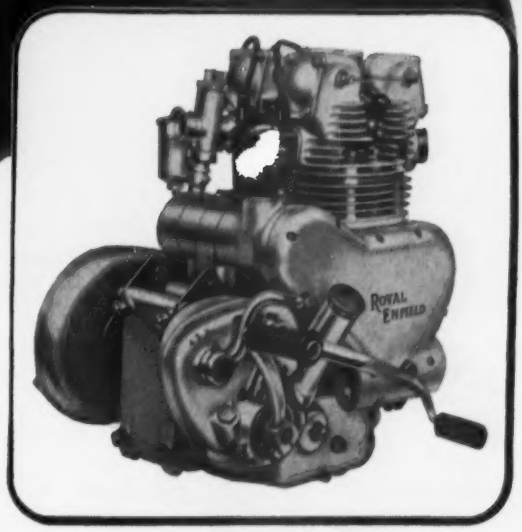

The engine of the Royal Enfield "500 Twin" motor-cycle in standard trim develops 25 B.H.P. at 5,750 R.P.M. and can reach 7,000 R.P.M. The crankshaft is a Harper casting. The Enfield Cycle Co. Ltd. say: "The excellent machining properties of the material, together with its mono-bloc construction, make this a much simpler production proposition than a built-up crankshaft, besides ensuring that it runs dead true at all times."

Harper quality covers iron castings, and also metal pressings, machining, enamelling and other finishes and sub-assembly work.

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The E.O. 600/95 Flat Engine
in the
LEYLAND ROYAL TIGER CHASSIS

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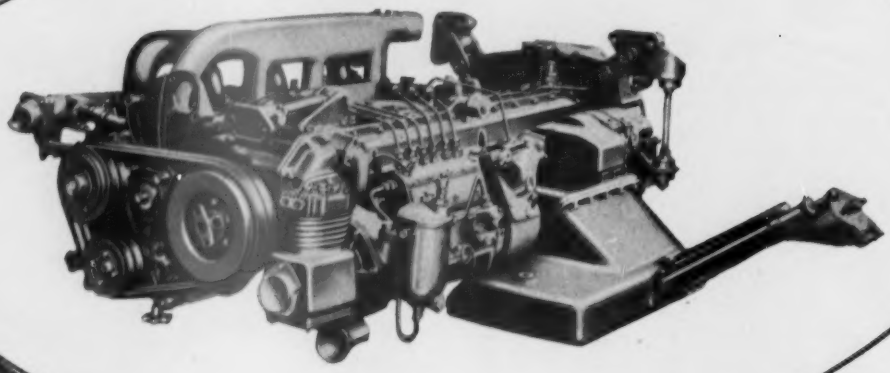

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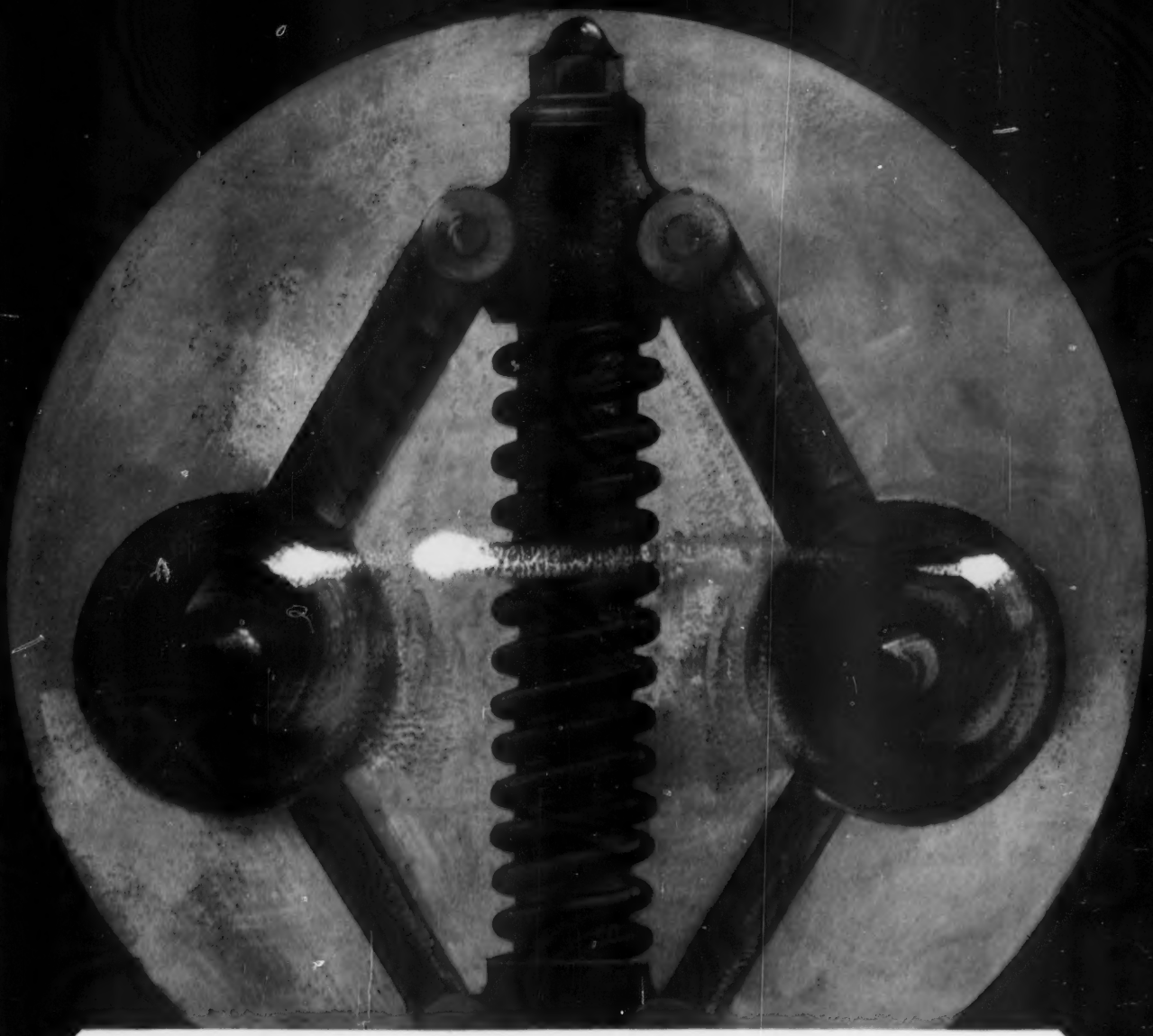

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The services of our engineers are at your disposal.

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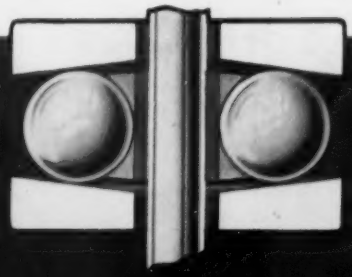

The care is there... in every SKF bearing

At every stage of manufacture the component parts of SKF bearings are subjected to many stringent tests to ensure long and satisfactory service. This illustration shows the inner ring of a spherical roller bearing being tested magnetically to ensure that it is free from fine cracks or material imperfections.

Such care in manufacture is your guarantee of reliability and lasting satisfaction in the finished product.

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Exhaust Valve Corrosion

ALTHOUGH motorists generally acclaimed the reintroduction of premium grade fuels, criticisms are now being made that their use causes accelerated exhaust valve corrosion. Experience, both in this country and America, does suggest that, in comparison with regular grades, premium fuels tend to cause increased corrosion. This is the price that has to be paid for fuels that will operate satisfactorily at high compression ratios. There is no immediate prospect that the problem will be solved or even alleviated by developments in fuel technology, and, at the moment, hopes of improvement lie with engine designers and metallurgists rather than with fuel technologists.

Points of attack

Corrosion may attack valves in various ways. As all automobile engineers know, by far the most serious and most frequent is corrosion of the seating face. This causes an imperfect seal and allows gas to leak past the valve face. The leakage not only has an immediate effect on the efficiency of the engine, but also leads to a rise in valve head temperature, which may be in the order of 200 deg C. This temperature rise accelerates the corrosion reaction until finally the valve cannot effectively close the combustion chamber.

Corrosion of the top of the valve is also frequently encountered. This is nothing like so serious as valve face corrosion, since it does not affect the functioning of the valve. It may, however, cause the valve to fail through loss of strength. Corrosion may also affect the valve stem. This can lead to breakage through the corroded section, with considerable consequential damage to the engine. Fortunately, failures of this character are rare.

To minimize face corrosion it is fairly common practice to weld a highly corrosion-resistant material to the base material of the valve, but even with this type of valve there may be fairly rapid deterioration at the junction of the two materials. The corrosion agents preferentially attack the valve base material and weaken the support for the welded layer. Such corrosion causes distortion and cracking of the valve face.

How far corrosion is caused by direct attack from elements in the exhaust gas stream, and how far by deposit-forming elements, has not been definitely established. It is known that tetraethyl lead has some effect and that sulphur and other impurities in the fuel also cause corrosion. Deposit-forming elements in the fuel or lubricating oil may also influence corrosion by forming deposits between the valve and its seat. Such deposits may lead to solid-state reactions which induce corrosion. Local ruptures in the deposit layers will permit combustion gas leakage, which will lead to higher valve temperature with accelerated valve corrosion. Any free oxidation in the exhaust gas stream will also cause oxidation of the valve material.

Fuel and lubricating oil

There is no doubt that products from the fuel and the lubricating oil are the chief agents in causing exhaust valve corrosion. So far as fuel is concerned, there does not seem to be any prospects of developments that will lead to reduced corrosion; on the contrary, to deal with increasing compression ratios, fuels will probably include additives which will increase corrosive tendencies. Oil technologists have, however, done something to improve matters by providing detergent lubricating oils. If these oils are used from the start of an engine's life, there is good reason for thinking that deposit formation will be greatly retarded, with a consequent reduction in corrosion. However, while detergent oils may afford a part solution of the problem, much more can be effected by engine design and by metallurgy.

It is not uncommon to find considerable variations in valve temperatures between engines of different design, but substantially similar displacement and output, and as temperature has an important influence on the tendency for corrosion to develop, this aspect of engine behaviour warrants more attention than it is often given. In addition to better cooling, which is an obvious step, improved engine breathing can help by reducing engine deposits. Valve rotation can also lead to considerable improvement.

Valve material

The problem of valve material is one of economics rather than metallurgy. Several highly corrosion-resistant materials are available for valves; unfortunately, they are relatively expensive and difficult to work. The use of protective coatings may prove a more profitable line of approach. In this country, the Brightray coating made by Henry Wiggin and Co. Ltd. has proved very successful in helping to combat corrosion. In America, General Motors have developed the Al-Dip process by which a coating of commercially pure aluminium is applied to the valve, either by a hot dip or a metallizing process. The aluminium reacts with the iron in the valve steel to form a

complex compound that is very corrosion-resistant. Engine tests on coated valves have shown that the life is increased from two to four times.

Suspension and Steering

EXPERIENCE of many makes of cars produced in this country and abroad indicates that, in general, both suspension and steering systems leave much to be desired. Power steering appears to have come to stay in America, and two manufacturers, one in the United States, and the other in France, have recently thought fit to depart from the conventional suspension arrangements. We refer, of course, to the new Packard arrangement and the Citroen hydro-pneumatic system. It is also worth noting that, in America, Ford and Chevrolet have adopted ball-joint front suspension for their 1955 models. In fact, it has been predicted that this type of front suspension will oust all others within five years in the U.S.A.

However, none of these innovations can yet be said to have withstood the test of time in normal service under different conditions throughout the world. Doubtless, conservative manufacturers will wait sceptically to see what develops, while the more progressive continue to experiment and test, aiming all the time at being able to offer something that is better than current practice and, at the same time, fully proved.

Even with conventional suspension and steering systems, there is still much room for improvement. It is not uncommon to see designs that in the development stage were obviously found to be fundamentally wrong so far as steering was concerned, but subsequently were improved by various devices, such as offsetting the rear axle relative to the spring centre, until they were acceptable, at least to the majority of users.

Weight distribution

Interaction between steering and suspension is complex and, of course, is always given careful study. However, other features that are of even greater significance are often left to chance in the design stage. One of these is the centre of gravity position. If the division of weight between the front and rear wheels is equal, at least the basic fundamental requirement for good handling is satisfied. Then, provided the camber, castor and other geometrical features of the suspension are correct, minor adjustments can, for example, be made to tyre pressures, to give slight under- or oversteer characteristics to suit individual preferences. In these circumstances, the final adjustments can be effected with the confident knowledge that after they have been carried out the vehicle will still be inherently stable. On the other hand, if the vehicle is fundamentally unsound, in that its centre of gravity position is incorrect, it can never be made more than merely satisfactory.

The centre of gravity position, in view of its significance, merits much more attention than it is currently given. Accurate records of its position in each new model that is introduced are useful. Nor is it sufficient to record only the front/rear weight distribution, for while the weight distribution along the longitudinal axis is of importance so far as steering characteristics are concerned, the vertical disposition of the main masses has a marked influence on roll during cornering and on roll-on under braking conditions. Most designs are almost symmetrical about the longitudinal axis, so it follows automatically that the lateral position of the centre of gravity is approximately mid-way between the sides of the vehicle; nevertheless, in less conventional designs this is not necessarily so.

Track width and wheelbase

Two fundamental considerations are frequently disregarded. One is that a wide track gives good handling characteristics and the other is that a short wheelbase leads to instability. With modern body styles there is a temptation to keep the track as narrow as possible to economize in materials; this is because an increase of the lateral distance between the wheels also involves widening the whole body. For this reason it is not uncommon to see on the smaller cars a partial reversion to the old-fashioned protruding wing type of body design.

Reduction of costs is also the reason for the tendency to keep the wheelbase to a minimum. However, this can be a false economy. Vehicles with an unduly short wheelbase tend to spin readily, particularly on slippery road surfaces. For this reason, such cars get a bad name and the demand for them falls off. As a result, the production run cannot be maintained for such a long period as for more popular models.

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HILLMAN MINX O.H.V. ENGINE

1·39 Litre Unit of Exceptionally Sturdy Design

THAT the new overhead valve engine for the Hillman Minx models has been introduced as an alternative to the well proved side valve unit of earlier design is, of course, well known. Some time ago, the side valve engine reached the peak of its development, and it is now difficult to envisage any direction in which significant improvement could be made simply by modification. In introducing the new engine, the manufacturers have decided that it should begin its course of development at a stage ahead of that at which the earlier design has terminated. Thus, the principal aim has been at the design of an engine that is capable of considerable further development to meet the ever-increasing demands that are likely to be made in the future on engines of this type. In fact, there is every reason to consider that basically this engine will not be out-dated even ten or fifteen years hence, although it will, no doubt, be subject to periodic modification.

In recent years in Europe, the trend has been for the power requirements for almost every class of vehicle to increase slowly but surely. This trend has been most marked in the United States, where the great demand for automatic transmissions based on hydrodynamic drives has greatly increased power requirements. Whether comparable increases in output will be called for when two-pedal controls are introduced in this country is open to doubt. Economic conditions on this side of the Atlantic are likely to force the development of more efficient forms of automatic and semi-automatic transmissions. However, it is unlikely that any manufacturer in this country would introduce a new power unit without taking these factors into consideration and allowing for any probable contingency.

The new engine has been designed in such a way that its power output can be increased appreciably without its approaching too closely the point where factors of safety become so small as to make the unit unreliable. For example, it is apparent that the bore diameter could be increased by about $\frac{1}{8}$ in if required. Moreover, the compression ratio could be raised, since the bearing areas are more than adequate for the current rating of the engine. This is a good feature, because the oil companies are continually improving the anti-knock properties of their fuels and it seems likely that this will lead to further increases in compression ratios among quantity-produced cars in general. No doubt, also, the crankshaft of this engine is stiff enough to enable the unit to be run at higher speeds if necessary.

A bore:stroke ratio of 1:1 has been adopted. The connecting rod length:stroke ratio is 1·92:1. At the speed at which maximum b.h.p. is developed, the mean piston speed is 2,200 ft/min. The maximum b.m.e.p. is 118 lb/in^2 at 2,200 r.p.m. The b.h.p. per square inch piston area is 1·52, and in terms of b.h.p/litre, a figure of 31 is obtained. Since the engine, complete with clutch-housing, dynamo, starter, air cleaner and fan and front mountings, weighs 330 lb, the output in terms of b.h.p/lb is 0·13. The overall dimensions of the unit are: length, from fan to bellhousing joint face, 23$\frac{3}{8}$ in; height, without the air intake silencer, 27 in; width, 17 in.

SPECIFICATION

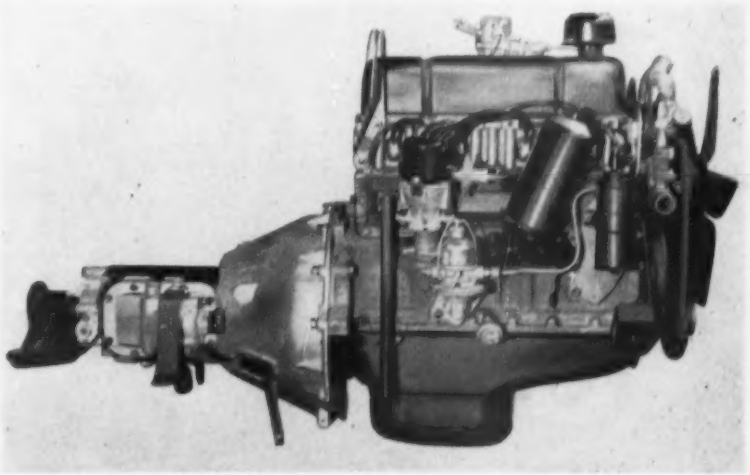
Four cylinders. Bore and stroke 3 in (76·2 mm) × 3 in (76·2 mm). Swept volume 85 in^3 (1,390 cm^3). Maximum b.h.p. 43 at 4,400 r.p.m. Maximum b.m.e.p. and torque respectively, 118 lb/in^2 and 796 lb-in at 2,200 r.p.m. Compression ratio 7·0:1. Forged, three-bearing crankshaft, fully balanced. Overhead valves, push rod operated, with camshaft in crankcase. Zenith 30 VI carburettor with 22 mm diameter venturi. Inverted bath tub type combustion chambers. A.C. mechanical fuel lift pump.

Cylinder block and crankcase

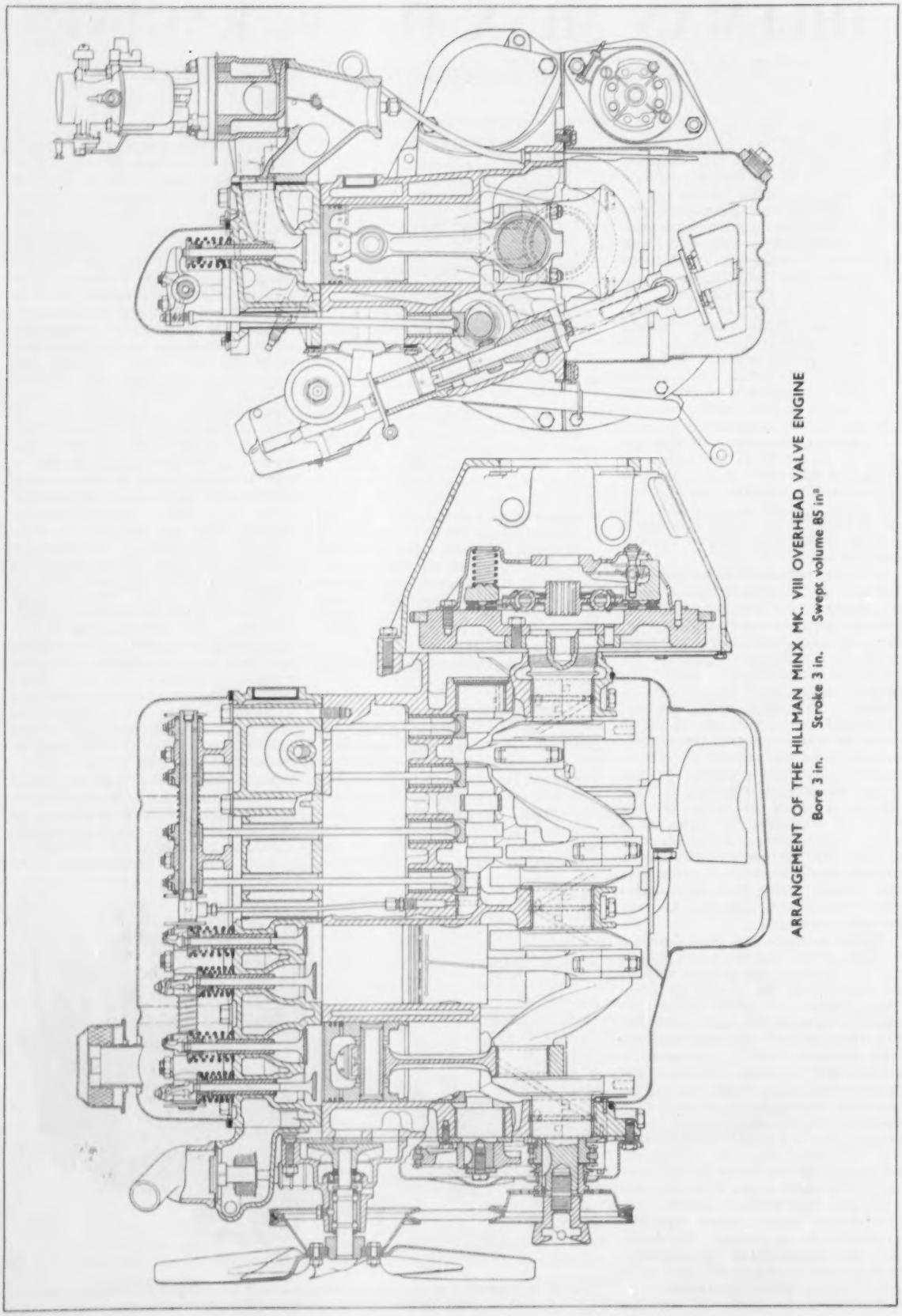
An integral cylinder block and crankcase unit of cast iron is employed. The camshaft is housed on the right-hand side. Its axis is about 3$\frac{1}{8}$ in above and 3 in to one side of that of the crankshaft; therefore, the camshaft cell only reduces the depth of the water jacket on that side of the cylinders by about $\frac{1}{4}$ in. The water jacket extends up to the level that is reached by the top rings of the pistons when they are at top dead centre. This is a good feature, since it is most desirable to make adequate provision for the transfer of heat away from the upper end of the cylinder walls, particularly in the area swept by the piston rings. The principal requirements in this respect, of course, are to keep the piston temperatures down to an acceptable level and also, by controlling wall temperatures, to minimize deterioration of the oil film where it is swept by the rings. If these two requirements are not met, troubles such as ring sticking, groove wear, piston failure and excessive rates of bore wear are liable to be experienced.

In the water jacket on the major thrust side of the block, a horizontal web is incorporated to connect the outer wall of the casting to the cylinder walls at a level about mid-way between their top and bottom ends. This has the effect of stiffening the cylinders and thus helping to prevent them from vibrating: high rates of cylinder bore wear are, in some instances, thought to be due to cylinder vibration. The incorporation of this also stiffens the outer wall of the jacket and thus helps to reduce the noise transmitted through that wall. However, it has the disadvantage of creating a discontinuity in the section of the bore but, as this discontinuity is in a relatively cool area, it is unlikely to cause distortion.

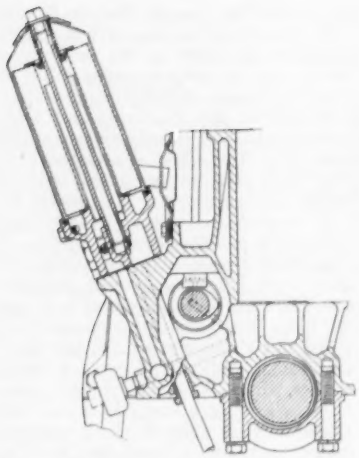
Since the cylinder walls are about $\frac{1}{4}$ in thick, there should be no difficulty in increasing the bore to provide an engine of slightly larger swept volume, should such a measure be desirable at a later stage of development. The



The full flow oil filter on the Hillman Minx overhead valve engine is inclined to improve access to the automatic advance and retard mechanism



ARRANGEMENT OF THE HILLMAN MINX MK. VIII OVERHEAD VALVE ENGINE
Bore 3 in. Stroke 3 in. Swept volume 85 in³



Section through the full flow filter and intermediate main journal bearing

thickness of the upper decking of the block is about $\frac{5}{16}$ in and in general the wall thickness of the water jacket and crankcase is $\frac{3}{16}$ in. Thus, there are no violent changes of section, so the block should be free from distortion. Moreover, because of the generous thickness of the sections, the stiffness of the casting is more than adequate. This should help to lead to silent running and a low rate of bore wear.

The skirt of the crankcase extends down to a level of about $\frac{1}{8}$ in below the axis of the crankshaft, and the main journal bearing cap seating faces are shouldered to a depth of $\frac{1}{4}$ in to locate the caps laterally. This arrangement gives adequate support for the main journals. Moreover, in the area in which the bearing loads are directly applied, the crankcase is compact and therefore rigid; this helps to keep crankcase vibration, and therefore the noise transmitted from the engine, to a minimum. By the adoption of this short-skirted layout, the manufacturers are able to employ a transfer type broaching machine to prepare the head and sump joint faces, the mounting platforms for the oil filter and ignition distributor, and the main journal bearing housings. The front and rear joint faces are machined between two pairs of end mills, one for the roughing cut and the other for finishing.

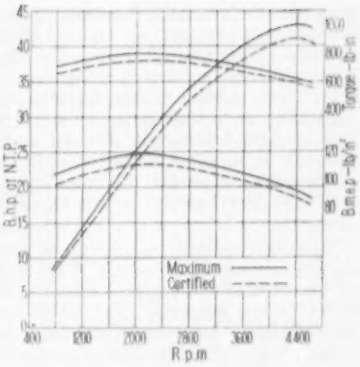
Some manufacturers extend their crankcase walls below the axis of the crankshaft and locate the bearing caps between deep shoulders in the end walls and transverse webs that support the main bearings. This measure, because it increases the overall depth of the casting, increases the stiffness so far as reaction of vertical forces is concerned; it also facilitates the sealing of the sump joint face at each end. However, it introduces production problems. Moreover, the increased depth of the skirt increases the area of the crankcase walls adjacent to the source of loading and so tends to increase the noise transmitted by them. It also adds to the weight of the engine. The short-skirted design is generally considered to be adequate for a moderately rated engine of this type.

A pressed steel sump is bolted to the broached face at the lower edge of the skirt. At each end, it has a semi-circular cut-out, which is lipped to seal on a cork strip round the bearing cap. A separate well, also of pressed steel, is seam-welded in an aperture about 6 in back from the front of the sump. In this way, the sump is made to clear the front cross member of the vehicle structure. A dished baffle is spot welded over this well. The edges of the sump are pressed to form a shallow, inverted channel section flange. In this channel section, two stiffening strips, about $\frac{1}{8}$ in thick, are seated, one each side, to ensure that an oil-tight joint is obtained when the sump is bolted up to its seating face. A two-piece, Corbex washer is fitted between the joint faces.

Crankshaft, connecting rods and pistons

The three-bearing, En9T crankshaft is fully balanced. All the white metal lined steel shell type main bearings are $1\frac{3}{8}$ in long $\times$ $2\frac{1}{4}$ in diameter. The estimated maximum bearing pressures, on the projected area, are: intermediate 1,217 lb/in^2; front and rear 780 lb/in^2. Thus, the bearing areas are all more than adequate for this engine rating. A circumferential groove is machined in the bearing face of each shell. Ribs round the caps ensure that their stiffness is adequate to prevent distortion when their holding down bolts are tightened. If adequate support is not furnished, bearing shells tend to close and their ends may even make metal-to-metal contact with the journals.

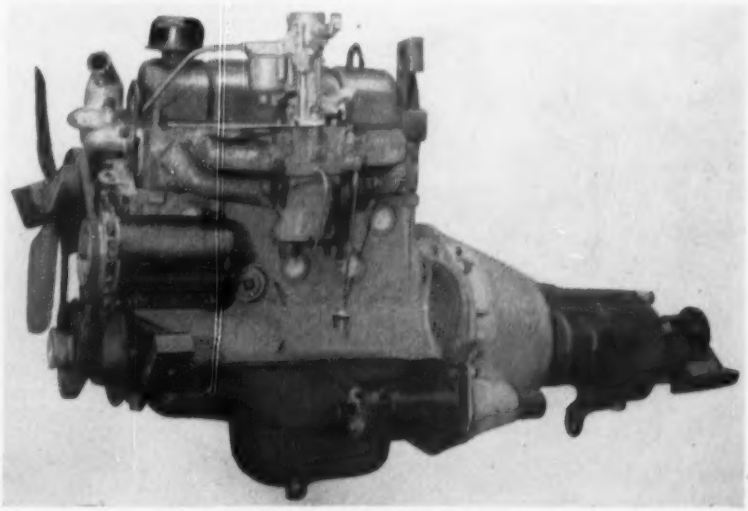
The crank pins are $1\frac{7}{8}$ in diameter and the white metal lined steel bearing shells in the big ends are $\frac{15}{16}$ in long. This gives an estimated maximum bearing pressure of 1,320 lb/in^2, so the loading of these bearings is relatively light. There is no oil grooving in the bearing faces. The big ends are split at right-angles to the axes of the rods. They can be withdrawn through the cylinder bores, so it is not necessary to remove the crankshaft to dismantle the piston and connecting rod assemblies.



Engine performance curves

Forged H-section connecting rods of En 15 are employed. Their minimum cross sectional dimensions are $\frac{1}{2}$ in wide over the flanges $\times$ $\frac{11}{16}$ in deep $\times$ $\frac{1}{4}$ in web thickness, and they weigh 1·62 lb, complete with the bearings. Phosphor bronze bushes, $\frac{7}{8}$ in inside diameter $\times$ $1\frac{1}{4}$ long, are pressed into the small end eyes. A $\frac{5}{32}$ in diameter countersunk hole is drilled in the upper end of the rod to allow oil to splash into the bearing. Balancing of each rod is effected by machining metal from two bosses, one on the upper end of the rod and the other on the big end bearing cap.

Plain, tubular section gudgeon pins, $\frac{7}{8}$ in outside diameter $\times$ $\frac{5}{16}$ in inside diameter, are employed. They are located by Seeger type circlips in grooves in the bores of the piston bosses. Many manufacturers favour plain tubular section pins because their strength and stiffness can be predicted



The two pieces of the deep, pressed-steel sump are seam-welded together

reasonably accurately, whereas those of internally stepped or tapered pins cannot. These pins are of En 206. They are case hardened to Rockwell C58. The surface finish specified is 6 micro-in on the outer periphery. A hole is drilled vertically through each piston boss to allow oil to splash in to the bearing surfaces in the cross holes. The effective bearing length in each cross-hole is $\frac{3}{8}$ in.

The flat-crowned pistons are of low expansion aluminium alloy. They are of the slotted skirt type. Pistons of this type are generally used in private car engines, because they can be readily made to fit the bore accurately. Also, their natural resilience enables them to take up most of the clearance between the skirt and the cylinder wall under cold as well as hot running conditions. As a result, the engine always tends to run quietly. Pistons of this type are also favoured for servicing replacements, since they readily adapt themselves to worn cylinder bores, and alignment is not critical. The pistons in this engine have horizontal, thermal slots beneath the ring belt to control the heat flow down the skirt and thus prevent local overheating.

In each piston there are two compression rings and one oil control ring, all above the gudgeon pin. At the top, a plain, rectangular section compression ring is employed. Its gap, as fitted, is 0·009-0·014 in. The cross sectional dimensions are: face width 0·0781-0·0771 in, and radial thickness 0·122-0·115 in. Between the ring and the groove the side clearance is 0·0035-0·0015 in, and the depth of the groove in the piston is 0·0806-0·0796 in. The second compression ring is of the same dimensions but is taper faced. A slotted oil control ring is employed. Its gap is the same as that of the compression rings, as are its radial thickness and side clearance. The face width is 0·1563-0·1553 in and the depth of this groove in the piston is 0·1588-0·1578 in.

A simple, leaf spring tensioner bears against the timing chain

Timing gear, camshaft and valve gear

The timing drive arrangement is conventional but the assembly in front of the sprocket on the $1\frac{1}{2}$ in diameter extension of the crankshaft is unusual. A lip type oil seal is not employed. Instead, the hub of the fan belt pulley has an oil return groove machined on it and operates in a $\frac{3}{8}$ in long × $1\frac{1}{4}$ in inside diameter sleeve welded in an aperture in the timing-drive cover. The inner end of the sleeve is lipped outwards so that oil draining down from the cover does not run over it on to the hub of the pulley, and a dished oil thrower ring is clamped between this hub and the timing drive sprocket. There are alternative pulleys, one is of unusual design in that it is a one-piece pressing which, together with a circular backing plate, is brazed on to a spigot on its cast iron hub.

A special bolt, which incorporates the dogs for the starting handle, retains the whole assembly. The head of this bolt is a Mazak die-casting on a $\frac{3}{4}$ in diameter stud; it is screwed into the front end of the crankshaft extension. A tab washer registers in the keyway in the hub of the pulley to lock the bolt. The pulley and the sprocket are driven by a single Woodruff key.

A two-strand chain, of $\frac{1}{2}$ in pitch, transmits the drive to the half speed wheel, the centre of which is $4\frac{1}{2}$ in from the centre of the drive sprocket. A Woodruff key transmits the drive between the half speed wheel and the camshaft. The wheel is retained by a $\frac{3}{16}$ in thick plate pulled against the end of the camshaft by a $\frac{1}{2}$ in diameter set bolt, locked by a tab washer that registers in a keyway in the wheel. A $\frac{3}{16}$ in thick thrust plate bolted to the front wall of the crankcase registers between the half speed wheel boss and the front bearing of the camshaft.

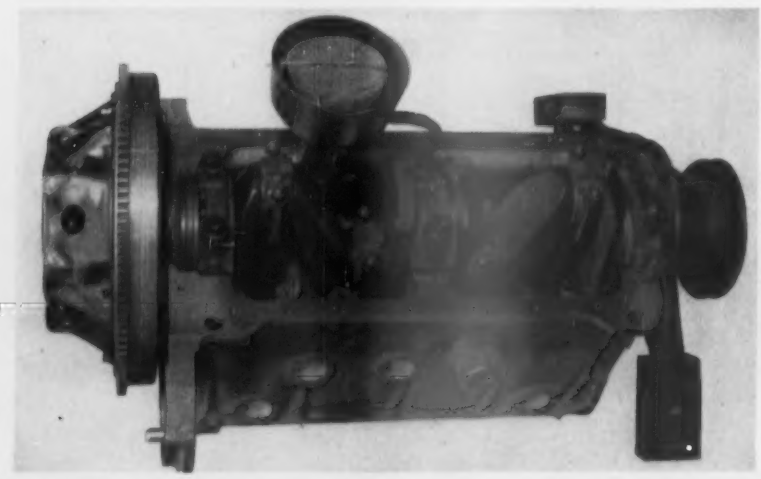
All three bearings of the camshaft are fitted with Vandervell L2866C bushes. This is a good feature, since it helps to ensure that the engine will run quietly for most of its life between major overhauls. Moreover, replacement of the bearings, when they are worn, is relatively easy. All three bearings are $1\frac{3}{4}$ in inside diameter. It is not unusual for the intermediate and rear bearings to be shorter than the front one because they are not so heavily loaded. However, in this engine they are all 1 in long in the interests of rationalization.

The camshaft is of cast iron and the cams are chilled. Between the cams it is 1 in diameter. The cam profiles have been designed to give silent operation and to avoid characteristics that would apply unduly severe loads to the valve gear. At 3,000 engine r.p.m., the maximum negative acceleration of the tappet, on the nose, is 1,298 ft/sec^2 and the maximum positive acceleration, on the flank, is 3,967 ft/sec^2. The nominal period of the cam is 126 deg and the lift is 0·255 in.

Chilled cast iron tappets of the piston type are employed. They are $\frac{7}{8}$ in diameter. A single drain hole is drilled near the base of each to allow oil to drain away. The wall thickness of the tappets is only about $\frac{1}{16}$ in. Thus, they are of light construction and inertia loading of the valve gear train is kept to a minimum.

The push rods are $\frac{1}{4}$ in diameter and their effective length is approximately $10\frac{1}{2}$ in. On each, a spherical lower end and a cupped upper end are upset. At one end of each cast iron rocker is the usual tappet adjusting screw and locking arrangement; the pad at the other end is chilled. The rocker ratio is 1·30:1.

A two-piece rocker shaft arrangement has been adopted. Each shaft is $7\frac{1}{8}$ in long × $\frac{11}{16}$ in outside diameter. Because of their short length, they are easy to machine accurately, and the two small assemblies are slightly easier to mount on the engine than a single large one would be. Each shaft assembly comprises two pedestals with the rockers on each side of them and a coil compression spring in the centre to hold the inner pair of rockers against the pedestals. Small conical spiral springs are fitted at each end to hold the outer rockers against the pedestals. Hairpin type spring



The skirt of the crankcase terminates at a level about $\frac{1}{4}$ in below the axis of the crankshaft: this facilitates machining

clips in grooves round the end of the shaft retain these springs.

A cupped steel plug is pressed into a counterbore in the front end of the forward shaft and the rear end of the rearmost one. An adaptor for the lubricating oil supply-union is fitted between the two shafts: spigots on the adaptor fit into counterbores in the adjacent ends of the shafts. The pedestals are of STA7/AC4 cast aluminium which, by virtue of their relatively high coefficient of expansion, reduce the tendency for the tappet clearance to close as the engine warms up. To locate the shaft, one of the pedestal holding down bolts in each of the intermediate pedestals registers in a groove machined in the periphery of the shaft.

The valves are arranged in-line in a vertical plane. A conventional two-spring assembly is fitted to each. The lower ends of the springs seat in a shallow counterbore round the valve guide housing and their upper ends bear against a shouldered washer retained by split tapered collets. Rubber rings are fitted in the lower ends of the shouldered retainer washers of the inlet valves to prevent excessive quantities of oil from flowing into the guides. The upper ends of the inlet guides are chamfered for the same purpose.

VALVE DATA

	Inlet	Exhaust
Material	En 52	En 59 (XB)
Head diameter	1·374-1·370 in	1·114-1·110 in
Throat diameter, port	1·25 in	1 in
Stem diameter	0·3110-0·3105 in	0·310-0·3095 in
Diametral clearance in guide	0·003 -0·0015 in	0·004-0·0025 in
Seat angle on valve and head	45 deg	44 deg 35 min and 44 deg 45 min
Face width on valve	0·10 in minimum	
Spring material	En 49C (Range 3)	En 49C (Range 3)
Spring rate:		
inner	73·8 lb/in	
outer	104·0 lb/in	
Spring length, free:		
inner	1·82 in	
outer	2·10 in	
Spring length, installed:		
inner	1·53 in	
outer	1·65 in	
Spring surge frequency:		
inner	22,700 cycles/min	
outer	20,400 cycles/min	
Number of coils:		
inner	6·25	
outer	5	
Coil outside diameter:		
inner	0·883-0·877 in	
outer	1·16 in	
Wire gauge:		
inner	0·110 in	
outer	0·14 in	
Spring retaining method	Cup and split cotters	
Valve lift	0·331 in	
Rocker ratio	1·30	
Valve crash speed	5,500 engine r.p.m.	
Valve guide material	cast iron	
Valve guide length	2·15 in	2·42 in
Valve guide inside and outside diameters	0·3135-0·3125 in i.d. 0·5640-0·5636 in o.d.	
Tappet clearance	0·14 in	
Valve opens	11 deg B.T.D.C.	53 deg B.B.D.C.
Valve closes	55 deg A.B.D.C.	13 deg A.T.D.C.
Ignition timing	12 deg or 8 deg B.T.D.C. according to grade of fuel used	

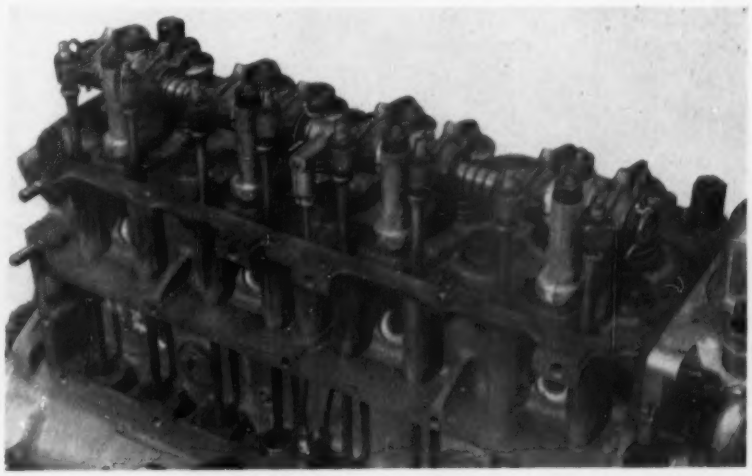
All the guides are of plain cylindrical section. Those for the inlet valves are approximately 2⅛ in long, while those for the exhaust valves are about 2½ in. The lower ends of the exhaust guides are chamfered to help to break away any carbon that might build up round the valve stems. Also to prevent carbon build-up, each exhaust valve stem is undercut between the neck and a point about ¼ in inside the lower end of the guide when the valve is in the closed position. This prevents the portion of the stem that is swept by the exhaust gases from coming into direct contact with the oil film in the guide. The lower ends of the exhaust valve guides terminate just inside their housings so that they, too, are not swept by the hot gases. This also ensures that they are well cooled. Again, this is mainly to prevent carbon build-up, but it also helps to avoid bell-mouthing.

The inlet valve guides do not need to be so well cooled and, since their ports are larger in diameter and are less sharply curved than the exhaust ports, as viewed in end elevation, their housings in the cylinder head are not so long. Nevertheless, the stems require to be adequately supported. It has, therefore, been necessary to extend the guides into the inlet ports, otherwise they would be too short to furnish this support. The lower ends of both the inlet and exhaust valve guide housings are machined square to the axes of the guides to facilitate the machining of the bores of the housings.

Valves with flat-topped heads are fitted. Some manufacturers favour this type, because they offer a minimum of surface area to conduct heat from the burning gases in the combustion chamber. They are also lighter than the mushroom type and so the inertia loading on the valve train is kept to a minimum. The ratio of the inlet valve head diameter to that of the exhaust valve is 1·7:1. This is high, as also is the ratio of the inlet valve throat diameter to cylinder bore, which is about 0·417:1.

Cylinder head, manifolds and carburettor

The cast iron cylinder head is about 3 7/8 in deep × 6⅛ in wide × 16½ in long. It is of simple yet sturdy design and the main masses of metal are disposed as symmetrically as possible to avoid thermal distortion. Two ⅜ in diameter studs and eight set-bolts, screwed into bosses in the top decking of the block, are used to pull the head down on to its ribbed steel gasket. The compression, in the head, caused by the tightening down of the two bolts at each end is, of course, taken by the end walls of the casting. All the other bolts are positioned close to the side walls, two between each pair of cylinders, and the casting is stiffened locally by an internal rib standing about ½ in above the lower deck of the head



A two-piece rocker shaft is employed and the lubricant is fed into it through an adaptor between the two adjacent ends

casting and extending laterally between the bosses through which the bolts are passed. The push rods pass through holes in flanges on the right-hand side at the top and bottom of the casting, and they are enclosed by mild steel tubes, pressed and peened into these holes. The water jackets are cored all round the housings of the inlet valve guides as well as those for the exhaust. Similarly, the exhaust valve seats are completely surrounded by coolant.

The combustion chambers are of the inverted bath-tub type and are offset to the right-hand side of the cylinders. This arrangement enables the sparking plug bosses to be incorporated on the right, where the plugs are readily accessible for servicing. It also leaves a shoulder on the left-hand side, which serves to give a squish effect and also to quench the end gases in the areas remote from the plugs. The plan form of the combustion chamber is more or less determined by the space requirements for the accommodation of the valves. The combustion chambers have horizontal tops so that the valves can be installed vertically; this, of course, to a certain extent simplifies machining operations. As viewed from the side, number 1 combustion chamber is offset about $\frac{1}{8}$ in forward of its cylinder bore and number 2 about the same amount rearwards. The same arrangement has been adopted in respect of numbers 3 and 4 cylinders. This layout, as can be seen in the illustration of the longitudinal section of the engine, permits the incorporation of an adequate water jacket space between the combustion chambers. Without this space, thermal distortion would be liable to occur because of uneven cooling. In addition, the arrangement facilitates the flow past the inlet valves, because their heads are well clear of the cylinder walls.

The outer edge of the lower flange on the right-hand side of the cylinder head forms part of the joint face, to which is bolted the pressed steel cover of the tappet chamber. The engine breather tube is welded into a hole in this cover. It has a pressed steel baffle over its inner end. This baffle is spot welded to the cover. The outer end of the pipe is scarfed and extended down outside the crankcase to the level of the top of the sump well. Air flow past the scarfed end tends to extract fumes from the crankcase, and fresh air enters through a wire-gauze air filter housed in the oil filler cap, which is on top of the pressed steel rocker cover.

The cast iron exhaust manifold is below the cast aluminium inlet manifold; the two are bolted together at the centre, where there is a thermostatically controlled hot spot. When the engine is cold, the thermostatic control valve deflects the gases into a jacket formed round the junction between the inlet gallery tract and the riser. A drain pipe is taken from the lowest point in the inlet manifold and a restrictor is fitted in to prevent undue weakening of the mixture in the closed throttle condition.

A Zenith 30 V.I. downdraught carburettor, with a 22 mm diameter venturi is mounted on a $\frac{1}{2}$ in thick, Cooper's No. 14 insulating block on top of the riser. It is screened from radiation from the exhaust manifold by an asbestos covered shield. The jets are as follows: main 80, slow running 55, compensating 75, fast idle 1·25 mm, progression holes 2 × 110. Fuel is supplied by an A.C. mechanical pump actuated by an eccentric on the camshaft. For the home market, an A.C., type Q, No. 7222759 air intake silencer is fitted, and the export models are equipped with an A.C. type No. E/AC7066 air silencer and cleaner unit.

Water pump and cooling system

The water pump is bolted to the front wall of the cylinder block. It is of conventional design and is driven at 0·96 times engine speed. The $2\frac{7}{8}$ in diameter rotor is pressed on to the rear end of the $\frac{1}{2}$ in diameter spindle. A spring-loaded, moulded rubber water seal, with a carbon thrust ring, is carried in the nose piece of the housing and bears against the front end of the boss of the rotor. In front of the seal, a thrower ring works in a drainage space.

A sealed tubular bearing, with the rows of balls spaced 1 in apart, carries the spindle. It is packed with grease on assembly and requires no further attention during service. Two grooves are machined round the spindle to form the inner races. The tubular outer race is located by a dowel-ended set screw assembled radially into the nose piece, with its dowel end projecting into a hole in the race. The hub of the pressed steel fan and pulley is pressed on to the $\frac{3}{4}$ in diameter front end of the spindle.

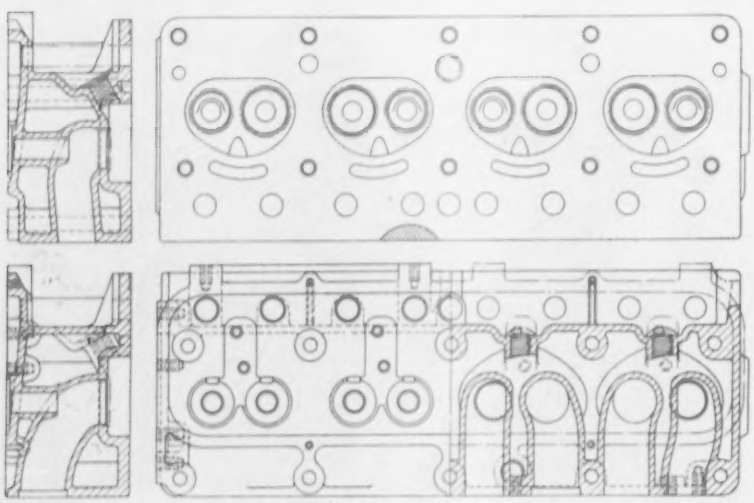
Water enters the pump from the radiator and is discharged into the cylinder block, where it cools the cylinder barrels and then passes up through slots to the head. These slots are positioned below the sparking plug bosses and as they are adjacent to the exhaust ports the cooling water is directed over the areas where it is most needed. A water outlet and thermostat valve is bolted to the front face of the head.

Oil pump and lubrication system

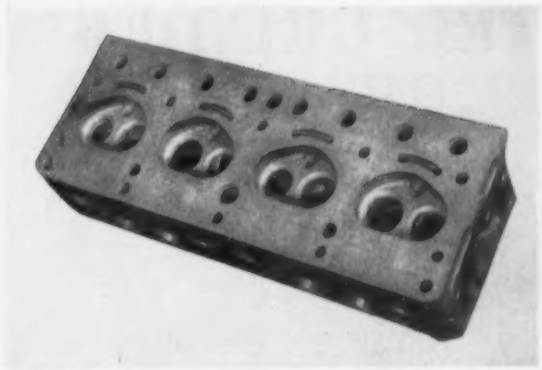
The oil pump is partly submerged in the sump, the capacity of which together with that of the filter is 8 pints. An inverted, cupped pressed-steel shroud is mounted over the gauze strainer on the intake of the pump. This shroud prevents sludge and particles from settling directly on the gauze and also helps to prevent air from being sucked in as a result of cavitation if the oil level is allowed to become too low.

A conventional Hobourne Eaton pump is employed. It is driven, together with the contact breaker and distributor, in the usual manner by a spiral gear on the camshaft. The pump housing is spigoted into a boss in the side of the crankcase. The neck between the pump gear chamber and the spigot end has an aperture cored in its left-hand side so that oil can be splashed in to lubricate the lower bearing of the drive spindle. The upper bearing, in the spigot end, is fed from the main gallery. Because of this positive oil feed arrangement, it has been possible to dispense with the more usual phosphor bronze bush arrangement at this end. The bore into which the spigot fits, breaks into the gallery, the restriction of which is avoided by the local machining of a groove in the spigot. From the base of the groove, a $\frac{1}{16}$ in diameter hole feeds the oil to the bearing surfaces. The length of the upper bearing surface is $2\frac{1}{4}$ in and the spindle is $\frac{1}{2}$ in diameter.

Immediately above the spigot, a sleeve, incorporating the spiral gear that meshes with the gear on the camshaft, is fitted over the end of the



The cooling passages round the valve ports in the cylinder head are particularly well arranged



A view of the cylinder head showing the combustion chamber arrangement

A thermostatically controlled hot spot is incorporated in the manifold assembly

spindle. Two $\frac{1}{4}$ in diameter pegs pressed into holes drilled diametrically through the sleeve and the spindle transmit the drive. The upper end of the sleeve is slotted to receive the tongue and dowel of the distributor drive. To obviate any possibility of the distributor being assembled 180 deg out of phase, the slots and tongues are eccentrically arranged.

The lubrication system is as follows. Oil is drawn from the sump, through the gauze strainer to the pump. Thence it passes through a $\frac{7}{8}$ in outside diameter pipe to a connection near the right-hand side of the web that supports the centre main journal bearing. From there it passes to the full-flow filter mounted on the side of the crankcase. A relief valve is incorporated in the filter head. The return from the filter is a $\frac{3}{4}$ in diameter hole drilled to join the $\frac{7}{8}$ in diameter gallery.

In the central web and end walls of the crankcase, $\frac{5}{16}$ in diameter holes are drilled transversely through the gallery to meet another set of holes between annular grooves in the main journal bearing housings and camshaft bearings. All except one of the transverse holes are sealed at the outer ends with screwed-in plugs; the unsealed one is closed by the oil pressure gauge connection. The feed holes to the main journal bearings are $\frac{3}{8}$ in diameter, but they are reduced to $\frac{1}{4}$ in diameter at the ends that supply the camshaft bearings. The annular grooves in the main journal bearing housings and caps are milled eccentrically relative to the axes of the bearings, and the oil is fed into them where their section is deepest. This ensures that the lubricant is distributed evenly through the four holes to each bearing surface. In the crankshaft, $\frac{1}{2}$ in diameter holes are drilled to supply the big end bearings. A jet is drilled in the big end of each connecting rod to splash oil into the cylinder bores.

From the feed hole, between the front main journal and camshaft bearings, a passage carries oil to a jet that is directed into the meshing point between the timing chain and its driving sprocket. The excess oil is taken through a pipe that passes down and into a hole, about $\frac{3}{4}$ in diameter, through the front main journal bearing cap, whence it is discharged into the sump. A baffle plate prevents the oil from discharging on to the front web of the crankshaft.

Two holes are drilled radially into the centre of the intermediate journal of the camshaft in such a way that once during every revolution they connect the oil feed to the bearing with an outlet to the rocker gear. The feed to the rocker gear is effected by means of a $\frac{5}{8}$ in outside diameter pipe between a union screwed into the outlet hole in the tappet chest and the brass adaptor fitted between the ends of the two rocker shafts. This pipe passes through a tube pressed into holes in the head flanges in the same way as the tubes through which the rockers are passed.

The oil passes through the brass adaptor into the hollow rocker shafts, and thence through radial holes into the rocker bearings. In each rocker a groove is machined parallel to the axis of the bearing to spread the oil over the surface Another groove is milled circumferentially in the lower half of the bearing bore to distribute the oil round the most heavily loaded portion. In each rocker a hole is drilled from the bearing surface to a point above the hardened end pads so that oil can pass out and run down to lubricate them. Another hole from the bearing surface communicates with a groove round the tappet adjusting screw. A radial hole is drilled from this groove into an axial one that passes the lubricant down to the spherical end of the screw. This ensures that tappet clatter is reduced to a minimum.

BUICK DYNAFLOW TRANSMISSION

Better All-round Performance

A STATOR assembly with variable pitch, instead of fixed, vanes is incorporated in the twin turbine Dynaflow transmission for 1955 Buick cars. This allows the transmission to have optimum efficiency in the cruising range and optimum acceleration in the performance range. Smooth transition from cruising to passing or performance operation is effected by changing the flow of the converter fluid instead of by shifting clutches or bands. The effect on performance of changing from low to high vane angle is greatest at low car speeds; it gradually decreases towards the coupling range which, at full-throttle operation, is about 60 m.p.h.

There are 20 blades in the stator assembly. Each blade is mounted on an individual crank pin that is actuated by the stator piston. Oil pressure on one or both sides of the piston moves the blades to either the low or high-angle position; the angle depends upon the throttle position. Throttle linkage from the engine actuates a valve in the high accumulator body. For throttle openings up to and including full throttle, low-angle positioning of the blades depends upon the application of high clutch oil pressure to the front side of the stator piston. High angle is obtained after full throttle is reached, the high clutch oil pressure being closed off.

TOOL AND CUTTER GRINDER

A New Cincinnati Machine With Many Interesting Features

THE latest addition to the range of tool and cutter grinders designed and built by Cincinnati Milling Machines Ltd., Birmingham, 24, is shown in the accompanying illustration. This machine, the No. 1 tool and cutter grinder, has a capacity of 8 in swing and 15 in between centres, and is designed for grinding and reconditioning miscellaneous small tools and cutters. It embodies many of the proven features of the larger No. 2 machine, but many new design features are incorporated.

The Cincinnati No. 1 tool and cutter grinder

Like the No. 2 machine, this new machine has a cartridge type grinding wheel spindle mounting, with a double row of special preloaded, precision anti-friction bearings, packed in grease for life-time lubrication. This construction promotes the smooth rotation that is necessary for a high quality surface finish on the cutting edge. After years of service, the cartridge type unit may be readily replaced, thus restoring new spindle performance in a matter of minutes.

A reversible ½ h.p. motor drive, built in to the wheelhead, provides the desired direction of grinding wheel rotation to suit any particular grinding application. There are two spindle speeds, 6,260 and 3,730 r.p.m., obtained through a tooth grip drive belt and sheave arrangement. The grinding wheel collets are quickly interchanged by removing a socket head screw.

An interesting innovation is the 360 deg eccentric wheelhead swivel. This adds 3 in to the conventional cross range of 4½ in and, therefore, facilitates surface grinding operations and ensures ample capacity for grinding large diameter cutters that require the full 8 in swing of the machine. It is a simple matter for the operator to adjust the wheelhead to any grinding position. Another advantage is that the grinding wheel is located right over the table surface with no additional saddle bearing length. This means less overhang with the wheelhead slide in the extreme operating position, and in most cases eliminates the use of spindle extensions.

The wheelhead pile (carrying the 360 deg wheelhead swivel and its built-in, instantly reversible motor drive and two-speed grinding spindle can be raised and lowered by the vertical elevating handwheel and swivelled 360 deg about its vertical axis. An elevating handwheel with a spinner type knob enables the operator to adjust the wheelhead quickly to any desired height.

The table runs on balls between hardened ways, a construction that gives unusual ease of movement. Curtain type dust guards at each end of the table protect the anti-friction table slide and the table movement operating controls from abrasive dust. Another design innovation is the swivel table "tange bar" setting device. Used in conjunction with precision gauge blocks, the taper setting device enables the operator to move the swivel table quickly and easily into the desired position for grinding angular cutters and tapered reamers; thus eliminating trial and error methods. The offset swivel table, with its unique setting device, not only ensures accurate taper grinding on work up to 2 in taper per foot, but also offers a secondary advantage. It may be swivelled 180 deg to increase the normal cross range by 2½ in. Duplicate controls give the operator the choice of operating the machine from the front, right-hand end of the table, or at the rear, right or left-hand side of the wheelhead.

Adjustable and retractable tailstocks that can be positioned anywhere along the table surface are fitted. Tightening the table clamping wedge bolts always locates the tailstocks from the straight side of the table slot to ensure accurate positive alignment of both centres. The retractable centre in the right-hand tailstock is adjustable for tension; this saves time when work is being removed for checking. A clearance setting dial on the left-hand tailstock enables the operator to obtain the desired clearance angle with speed and accuracy when arbor mounted cutters are to be ground.

The universal workhead has an anti-friction spindle mounting which ensures a smooth easy movement when rotating the spindle from one grinding position of the work to another. This is advantageous in obtaining a fine finish on the cutting edges. The double-end spindle accommodates No. 12 B. and S. (No. 5 Morse optional) taper shanks at one end and No. 50 series National Standard taper shanks at the other. Clearance setting dials on the workhead afford convenient and accurate setting for predetermined clearance angles.

Particular attention has been paid to lubrication to give simplicity of oiling in conjunction with maximum service. An oil shot pressure unit located in the wheelhead slide, lubricates the wheelhead slide bearings, the wheelhead vertical adjustment mechanism and the cross-feed screw. This efficient lubrication system, together with the table slide construction, grease-packed spindle bearings and sealed wheelhead column, ensure trouble-free performance.

A wide range of specially designed attachments, which greatly extend the range of work for which the machine can be used, may be supplied at extra cost.

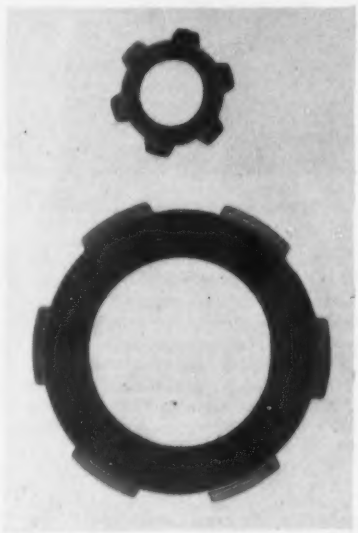
SINTERED METAL FRICTION MATERIALS

Clutch and Brake Facings for Heavy-duty Applications

ALL friction applications involve the conversion of mechanical energy into heat, the absorption of this heat, and its eventual dissipation. Conventional friction clutch facings and brake linings usually are of asbestos fibre base bonded with resin, and friction coefficients in this material are varied by the inclusion of brass swarf, cast iron grit and other suitable fillers. While materials of this type are in common use and perform effectively in many applications, they have certain limitations and disadvantages in other duties. Resin-bonded asbestos materials can be used at temperatures up to the region of 370-400 deg C and naturally a material of metallic base will be capable of withstanding substantially higher temperatures without suffering excessive wear and distortion. To this end a sintered bronze friction material has been developed by Sintered Products Ltd., of Sutton-in-Ashfield, Notts. It is produced in several different grades and is marketed by Small and Parkes Ltd., Hendham Vale Works, Manchester 9, under the trade name of "DON."

Friction facings are produced by the powder metallurgy technique, which enables them to be moulded in extremely thin sections so that the fullest use can be made of their high wear-resistant properties. Providing a grade of material having a high coefficient of friction is selected for use, the design of clutch units smaller and more compact than would otherwise be necessary for a specific duty will be facilitated. Operating experience has shown that these facings are but little affected by the ingress of oil or moisture, or by other extraneous factors.

In comparison with solid metal plates the sintered components show a marked advantage. The method of production is such that the friction-augmenting ingredients, in any desired proportions, can be evenly distributed throughout the structure. Such uniformity cannot be attained in solid metals, which, under heavy-duty conditions, tend to gall, to vary in friction coefficient, and to wear rapidly.

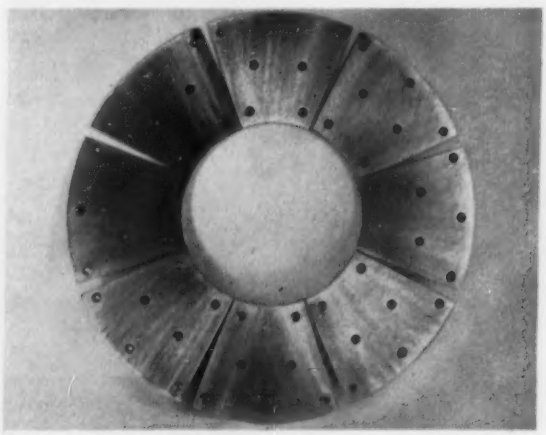


Clutch components for aircraft engine auxiliary equipment. "DON" S4 quality. Facing diameters 1 in and 2¾ in approx

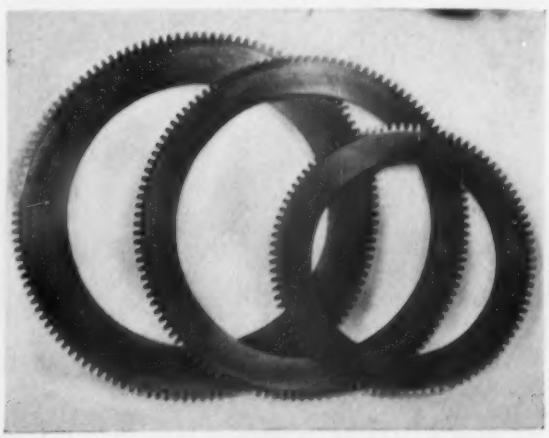
The manufacture of powder-metal friction materials entails more operations than are generally required in other powder metallurgy techniques. In the main this is due to the need to incorporate a structural support member, invariably of sheet steel, to sustain the peripheral loading encountered in service. By itself the sintered metal is insufficiently robust to perform that duty. The composite component, usually in the shape of an annulus, consists of a flat steel support plate with friction elements metallurgically bonded to one or both faces. Plates of this type can be produced in all sizes up to 20 in diameter.

Larger diameter plates are made by bonding separate sectors of friction material directly to the support plate. For clutch plates of the largest sizes the individual sectors are bonded to thin steel backing plates of similar shape and then riveted or welded to a steel carrier plate. By this method it is possible to produce plates in sizes exceeding 48 in diameter. The thickness of the facing is related to the diameter of the plate which, of course, is determined according to the torque it is required to transmit. A small clutch plate for a machine tool application may have facings only 0·010 in thick, while for units of large diameter operating under heavy loads a thickness of 0·250 in is not uncommon.

A sintered metal facing will not necessarily cover the steel support plate completely. Where the size of the steel plate is predetermined by an existing clutch design it may be advantageous to reduce the radial width of the facings in order that the specific loading on the friction surface



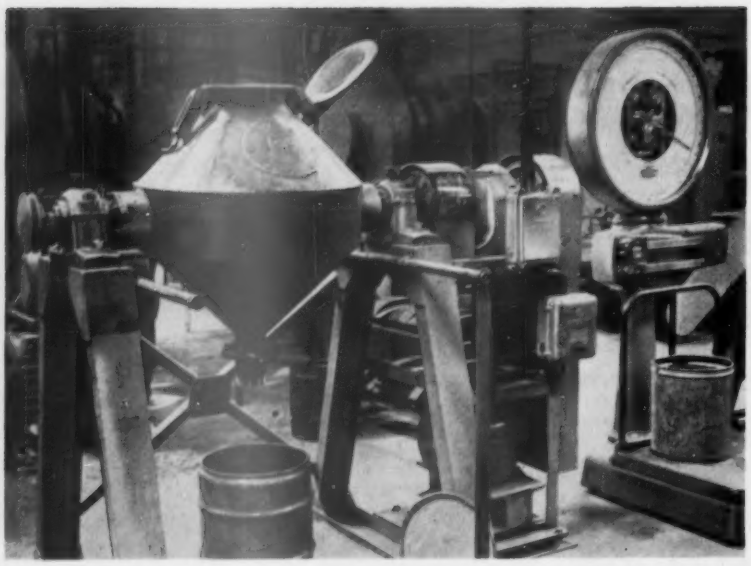
Master clutch plate for Caterpillar tractor. "DON" S1 quality. Facing diameter 18 in approx



Plates for Caterpillar steering clutches. "DON" S2 quality. Facing diameters 15½ in, 14½ in and 11½ in approx

be increased. This has the effect of improving the operating consistency of the clutch, of reducing take-up time, and also of assisting the "bedding-in" of the plates.

Owing to the low wear rate of the material the bedding-in time tends to be relatively long and consequently a high degree of parallelism is necessary to restrict this period to a minimum. Careful control during production and a final precision grinding operation ensures that finished plates of small and medium sizes are parallel to within 0·001 in. A wider limit can be specified for the larger sizes.



Powder weighing and mixing station

Production technique

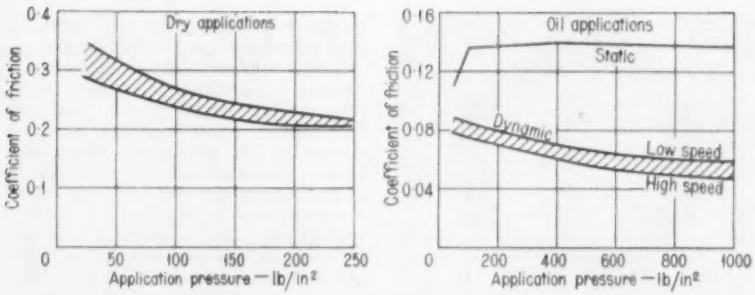
Powder mixing: Samples of all powders used are examined in the laboratory for particle size, shape, and chemical content before bulk consignments are passed into the shop for production use. All the various constituents are carefully weighed out in the correct proportions and then fed into a rotary mixing drum in accordance with a prescribed procedure. The mixing drum is of the double-conical type rotating on an axis normal to the axis of the cones. After a thorough mixing the powder is transferred to air-tight containers for storage.

Compacting: The powder mix is fed into the cavity of a forming tool and subjected to a uniform pressure, commonly between 10 and 15 ton/in^2, in a hydraulic press. In the usual manner, the feeding operation is carried out by means of a reciprocating hopper mounted on a sliding shoe in which is an aperture of limited area. A blade attached to the shoe corrects the height and density variations of the powder in the cavity, leaving a smooth and level surface. The press is then closed and the powder compacted.

Stresses set up in the compact during compression produce a tendency for it to expand and crack on ejection. To prevent this contingency, the compact is rigidly retained between the upper and lower punches whilst the dies are stripped downwardly by compressed air. The press head is raised after ejection and the compact is then slid forward on to a tray for removal and stacking. As lead and

Compacts are produced on a 2,000 ton hydraulic press

Sintering furnace, with stack of clutch plates in position



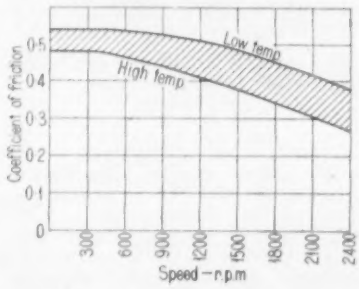
"DON" S1 material. Coefficient of friction v. application pressure. Dry and wet applications

silica powders are present in the mix in finely divided form, below 300 mesh, dust extraction equipment is installed to draw off any airborne particles.

The tendency of the compact to expand on release from the press results in a slight increase in volume and a consequent lowering of density. Control of this factor can be effected either by compacting to a higher initial density than the designed value, or by restoring the designed density by a coining operation.

Steel support plates: Usually these plates are in the form of rings having splines or teeth on the periphery or the bore. After piercing and blanking they are turned to size on outer and inner diameters. Teeth are then either blanked out or gear cut, depending upon the quantities required and the tolerances specified. A typical example is a ring in En 42, $\frac{3}{32}$ in thick and $15\frac{5}{32}$ in outside diameter. These are gear cut in stacks of 45 plates and are subsequently faced on each side with friction material $\frac{1}{64}$ in thick. In preparation for the sintering operation the plates are chemically cleaned and either copper or nickel plated. The plating protects the critical surfaces from harmful oxidation and assists in the formation of a metallurgical bond between the friction material and the plate.

Sintering: Compacted rings are assembled with their support plates in a vertical stack on a loading fixture. They are located on their bores and separated by spacer plates of stainless steel specially treated to prevent adhesion to the compacts. The completed stack of from 80 to 100 plates is cramped to prevent movement and then lifted clear of the loading fixture and lowered on to the base of a bell-



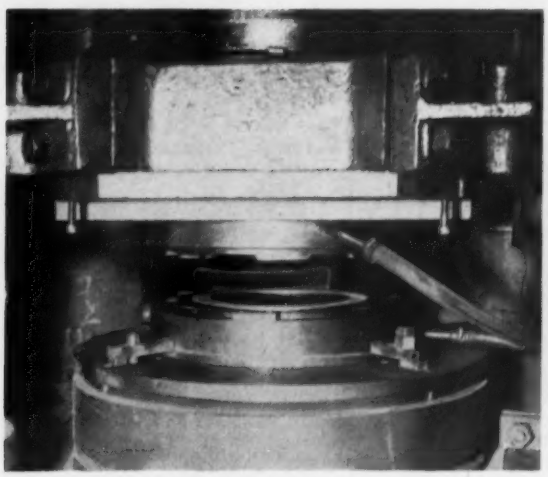
"DON" S2 material. Coefficient of friction v. speed. Dry application

type electric furnace. In this furnace is an axially positioned, vertically slidable, steel column which is actuated from below by a pneumatic unit capable of exerting a maximum load of 15 ton. A steel cap is fitted over the stack and attached to the control column and a pressure of between 100 and 150 lb/in² of the surface area of the plate being processed is applied to the stack.

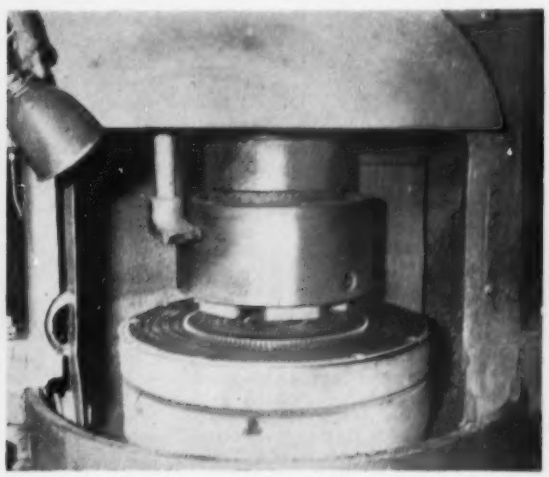
An atmosphere can is then placed over the stack and sealed at the base in chrome ore. A protective atmosphere—burnt town's gas—is maintained within the can throughout the cycle. The heating bell is lowered over the can and sealed at the base and the temperature is raised to between 750 and 880 deg C, according to the type of material being treated. In total, the complete cycle of heating, holding, and cooling may extend to about 12 hr. This combination of heat and pressure sinters the friction material and forms a firm bond with the support plate.

A complete furnace unit consists of three bases, the heating bell being moved from one base to another between cycles. The critical temperature is maintained for one hour before the removal of the bell. During the cooling phase, which may last 6 to 7 hr, the atmosphere can remains over the stack of sintered components, maintaining the reducing atmosphere until the temperature of the stack is lowered sufficiently to prevent oxidation. Included in each stack are three test rings which, after sintering, are submitted to a series of physical tests in the laboratory to ascertain whether the material is suitable for processing through the follow-on operations.

Finishing: As the sintering operation compresses the layer of friction material, some slight distortion may occur at the outer and inner diameters of the material. Where this is coincident with a control dimension, a finish turning or boring operation is performed in a lathe faceplate fixture. Before submission to final inspection the composite plates are corrected for thickness, flatness, and parallelism by a surface grinding operation. Lumsden disc grinders with magnetic tables and Gardner double-disc machines are used for this work. A satisfactory finish in minimum time is obtained with an



Compacting tools on hydraulic press. A clutch ring compact has just been ejected



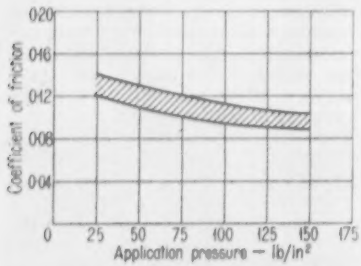
After sintering the clutch plates are finished by surface grinding

Alundum 80 wheel removing about 0·010 in stock from each face.

Shaped friction facings

The production of facings in curved or conical form presents quite varied problems and necessitates a modification of the technique employed for flat facings. The coefficient of friction of a facing to some degree affects its ductility. The inclusion of large quantities of abrasive, non-metallic elements to provide high friction values results in material which fractures during forming or rolling, even when bonded to a steel supporting strip. This also applies to components which have thick sections of small radii, as the inherent moment of resistance of the material is normally too low to withstand the stresses set up in the mechanical bending operation.

It follows, therefore, that some measure of preforming must be effected where thick sections are required and where the material is necessarily of a brittle nature. This is accomplished by producing the segment in curved form at the compacting operation. The compacts are then stacked vertically in the sintering furnace as before and pressure is applied by means of male and female formers located at the top and bottom of the stack respectively. After sintering the components are drilled,



"DON" S3 material. Coefficient of friction v. application pressure. Oil friction test on automatic transmission application. Room temperature 300 deg F

counterbored, and any dimensional inconsistencies on profile are corrected by grinding.

Material composition

The composition of the material is of paramount importance in respect of performance characteristics since relatively slight alterations in individual ingredients may result in wide changes in friction coefficient and wear resistance. There may be eight or more different ingredients, including non-metallic items, in a mix and it is necessary, therefore, for close control to be maintained over the weighing and blending procedure. The metal matrix generally consists of a large proportion of copper with additions of other metals such as tin, lead, and iron. Friction-producing ingredients such as silica, felspar, and emery are incorporated and also a small proportion of graphite.

Clutch plates for machine tool applications. Special quality. Facing diameters 4 in and 4½ in approx

Copper is ideal for use as a base metal because of its high thermal conductivity and its resistance to frictional heat during service. Since this powder is produced by an electrolytic process its particle shape and inherent plasticity are especially advantageous during the compacting operation.

Tin may be included in amounts varying from 3 to 10 per cent. This low melting-point metal diffuses into the copper during the sintering operation to form a bronze which has improved strength. The high apparent density of the tin powder assists in the consolidation of the pressed compact.

Iron is added in amounts of 5 to 10 per cent, its purpose being to increase the coefficient of friction. The relatively harder iron particles contained in the soft copper-base matrix prevent or minimize the tendency of the friction surfaces to pick-up on the opposing plate.

Lead, a virtually insoluble material, is added in percentages of 1 to 10 per cent. During operation it exudes to form a lubricating film on the surface if the temperature exceeds the melting point of the metal. A self-regulating effect is set up by the lubricating film as the friction coefficient is lowered and the heat generated is reduced. The lead inclusion also facilitates smooth engagement and prevents erratic action.

Graphite is added in quantities up to 8 per cent and has useful properties both in manufacture and in operation. It acts as a lubricant during the compacting process and ensures a smoothly engaging lining in service. Flakes of a coarse nature are used in some mixes to break up the metallic ingredients and force the friction-producing refractory materials to the interface, thus increasing the friction coefficient.

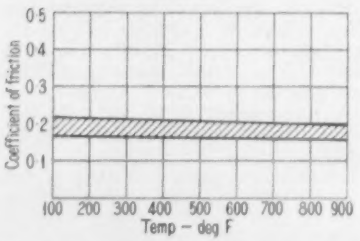
Silica, felspar or similar finely divided friction-augmenting substances are included in amounts varying from 1·5 to 7 per cent. Accurate control of the proportion of abrasive powder is demanded during weighing as small deviations may seriously effect the coefficient of friction.

Molybdic oxide powder up to approximately 4 per cent is included in mixes for heavy-duty clutches. This substance stabilizes the friction coefficient over the extreme temperature ranges often experienced in applications of this type.

At present sintered bronze friction material is manufactured in four standard qualities.

"DON" S1 is suitable for dry-friction applications in track-laying tractor master clutches, disc-type aircraft brakes and other heavy-duty equipment. This material does not suffer from shell-out, glazing, or heat-checking and the effect on the opposing surface is gentle with little wear and virtually no bronze pick-up. The wear rate of "DON" S1 increases with temperature rise but is not excessive up to 650 deg C. This quality also performs adequately as a wet-friction material.

"DON" S2 is particularly suitable for the steering clutches of track-laying tractors because of its high



"DON" S4 material. Coefficient of friction v. temperature. Dry application

friction characteristics under conditions of low speed and static engagements. The friction decreases with increase of temperature and speed of engagement, although at temperatures up to 370 deg C and speeds at 1,000 ft/min the coefficient remains high at 0·4 to 0·5. The mechanical properties of the material are good and it does not gall, shell-out, or score the opposing face.

"DON" S3 was designed primarily for wet-friction applications where high static and dynamic friction coefficients were desired. This material is eminently suitable for automatic transmission clutches and its coefficient of static friction is 0·13 to 0·15 at 20 lb/in². The wear rate is similar to that of the two previous qualities.

"DON" S4 is recommended where uniform friction is required and a low coefficient of friction can be tolerated. The dry friction coefficient is approximately 0·2. Its characteristics and its extensive life make it an appropriate selection for slipping clutches.

COACHWORK DESIGN

A Review of the Outstanding Winning Entries for the I.B.C.A.M. Competition

FOR many years the drawing competitions arranged annually by The Institute of British Carriage and Automobile Manufacturers in association with The Society of Motor Manufacturers and Traders Ltd., The National Federation of Vehicle Trades, and The Worshipful Company of Coach Makers and Coach Harness Makers, have attracted the attention of draughtsmen of all ages. There have been occasions when the support given to the several classes has not been as great as was hoped. However, despite fluctuations of the numbers of entries from year to year, the standard of design has never suffered materially.

This year is no exception and although the private car sections featured one common type of saloon design, it was interesting to study the different lines of approach adopted by the competitors in their attempts to achieve an outstanding model within the framework of the general theme of the specification. It can safely be said that in every case the awards were well deserved and the competitors have obviously devoted considerable thought to the finer aspects of their designs. This is particularly so in the case of the commercial, passenger-carrying vehicle, for which elaborate perspective views were entered. The coloured drawing work was excellent; and, in contrast with some earlier competitions, amongst the successful entries there was little in the colour schemes that could be regarded as inharmonious. Some of the outstanding exhibits have been selected as the basis for the following review.

Competition No. 1

This competition was open to persons of British nationality, without age limit, and was for a coloured drawing of a four-door six-seater saloon, together with separate sketches in line or colour of details such as interior trimming, luggage accommodation, the instrument board layout and similar items. It was intended that such supplementary drawings should be suitable for supporting a sales campaign, or, alternatively, for catalogue illustration. The coloured drawing was required to be to a scale of approximately $\frac{1}{4}$ in to the ft, and a three-quarter front view was specified; in the completion of this drawing either hand brushing or mechanical means could be used. No chassis drawing was provided and the entrant was free to design his own chassis to suit the body he had in mind, the one limiting condition being that the wheelbase was to be 9 ft.

The first prize of £50 and the Company's medal was awarded to S. A. Batchelor, who submitted a very pleasing design. From the supplementary drawing it can be seen that ample interior accommodation both for passengers and luggage is available. In this design, great care has been taken to reduce so far as possible the substance of pillars and quarter panels above the waist line, with the result that there is a commendable increase in visibility from the interior. Moreover, this light roof effect agreeably reduces the proportions of the main mass. The front and rear wings are united by the body side panel and there is no line of demarcation between either wing and the body shell itself. However, the effect is not heavy, since the maximum width over the wings is reduced some distance below the waist line to create a rounded shelf running from front to rear.

In the rear wing design this competitor has given some thought to the question of stability when a car travels at high speed. Above each rear wheel there is a substantial fin, which extends with increased depth to the rear end of the body. The fin forms the rearward extension of the inset portions of the wings, although these sections could be regarded as the body side panels.

An interesting feature of this wing and body-side treatment is that the upper inset section of the wing, or body-side panel, extends along each side of the bonnet to house, behind its extreme front edge, the head lamp. It is difficult to see just why this method

The first prize winning design in Competition No. 1, by S. A. Batchelor. An interesting feature of this vehicle, which has been given the name of "Figaro," is the head lamp arrangement

of lamp accommodation has been chosen, for it would seem that in such a position the head lamp beam would be cut off to some degree, and a full width beam such as might be required when driving in fog would to some extent be restricted by the sides of the lamp housings. Without doubt, some of the illumination required in these circumstances is supplied by the lamps that are situated in the recess at each side of the orifice at the base of the front panel, which apparently admits air to the radiator grille.

The four doors are hung on their forward pillars, and to reduce substance above the waist, the upper portions of the doors consist of metal frames. All doors have drop-windows and pivoting ventilation panels. It is interesting to note that the interior coloured drawing shows the usual winding handles that indicate a window mechanism of the conventional type.

In the layout of the interior, the bench type front seat is split on the near-side of the driver to permit the front passengers to adjust their seats separately. Another interesting point is that the near side portion of the front seat has a hinged squab that can be folded down to the rear seat cushion, thus providing a bed. Arm rests, which also act as pulls, are fitted to each door. In these days, when so much emphasis is placed on road safety, it is interesting to find that this competitor equips the portion of the facia immediately below the windscreen with an anti-crash pad, composed of foam-latex covered with leather. This has been done before, but the idea is carried a stage further in this design in that the pad is continued on each door, to dispense with the usual door facia.

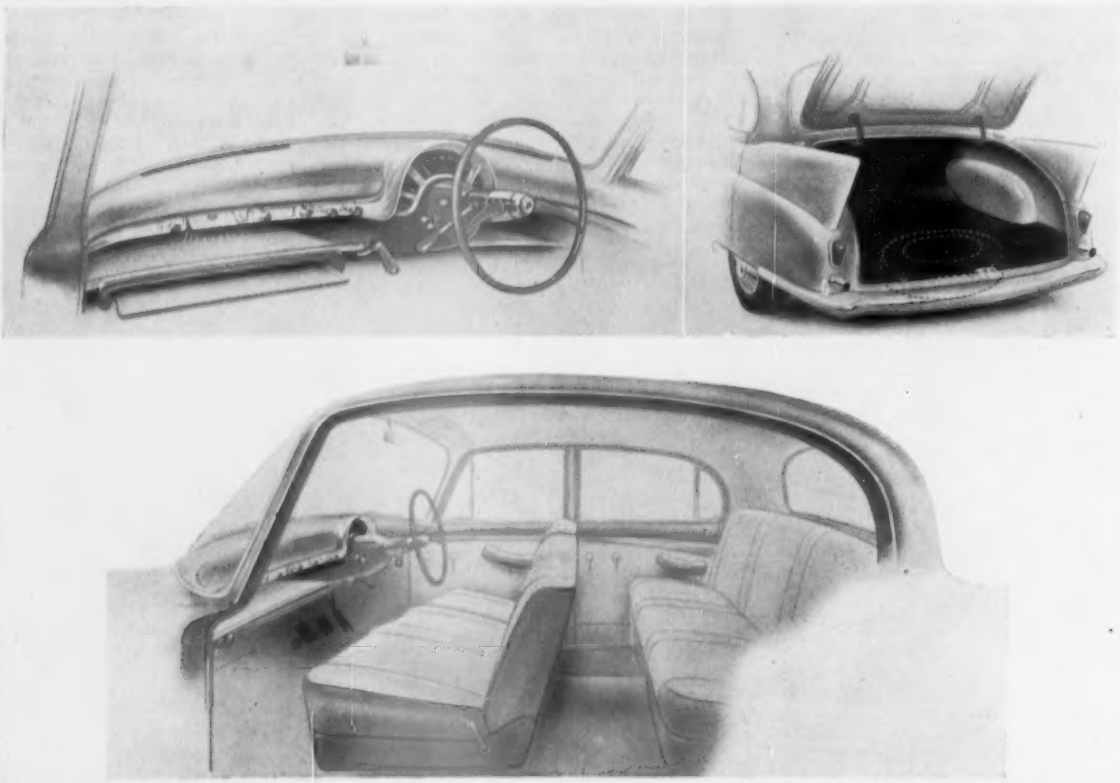
Another feature of the interior is that provision is made for the fitting of an electric demister for the rear window. The Perspex windscreen has good inclination and is curved in plan. It has an increased radius at each side to lead the glass into the normal inclined screen pillar. The screen pillars have an inclination at the top to suit the windscreen, but below the waist are swept forward to meet a vertical section extending from the body sill to give increased leg room to the occupants as they enter the car. This is particularly desirable in view of the fact that the front doors are hinged on these pillars. Passengers should find that entry to the front seats is relatively easy and, since there are no control levers at the off side, the driver also will have no difficulty in entering the seat.

There appears to be ample accommodation within the luggage boot, which is provided with a lid embracing both upper and rear panels. This lid is hinged at its forward edge. The spare wheel is arranged in a cradle beneath the floor of the luggage boot. It is lowered by engaging the wheel brace with a hexagon headed screw, the action of rotating the wheel brace lowering the cradle.

In addition to the coloured drawing and that showing the interior arrangement, a line drawing giving dimensions of seating, boot accommodation and general panel formation of the body is included. This drawing, together with others submitted by the entrant, is faultlessly executed.

Competition No. 2

This competition was open to persons of British nationality, without age limit. A general arrangement drawing, in ink, to a scale of 1½ in to the foot, of a four-door six-seater saloon had to be submitted. It had to include sufficient details to show the method of construction and the views had to include the elevation, half plan, half front and half rear views. An essential requirement was that the elevation should depict a car travelling from right to left. Although this is the conventional aspect, it should be remembered that it has not always been adopted and the judges' task, therefore, has been made more difficult. A further instruction was that the half plan view was to show the left-hand side of the car. No chassis drawing was provided, but the designs submitted were required to suit a chassis having a wheelbase of 9 ft, all other chassis details being left to the



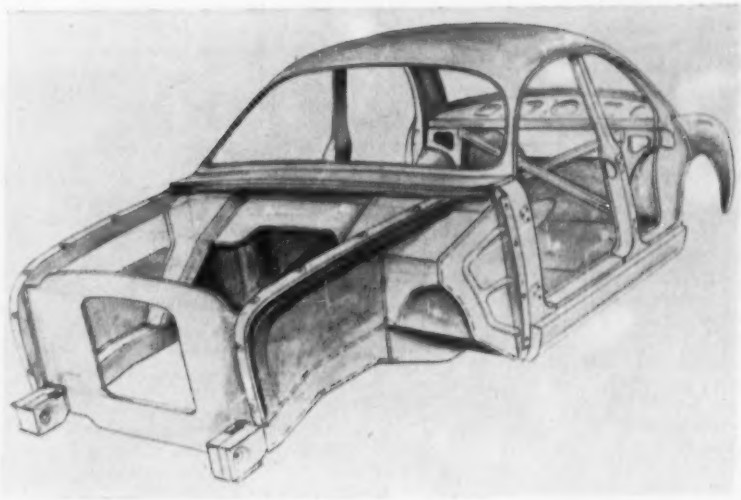
Some of the interior views of the first prize winning design for Competition No. 1. The foam-latex filled, crash pad arrangement on the dash facia is continued round the sides to form the waist rail

discretion of the competitor.

The first prize of £50 and the Company's medal was awarded to Geoffrey J. Clarke, who submitted a pleasing design in which the continuous wing treatment is used. In this case, however, the upper line of the wing has a slight fall as it crosses the front and rear doors and is then upswept to give appropriate rear wing line. The doors are hinged on their forward pillars. To facilitate accommodation of the hinges, a portion of the scuttle pillar is extended vertically below the waist; above this, the pillar is inclined to suit the screen line. The screen has transverse curvature and similar treatment is adopted for the back light.

Of the three sheets that comprise this entry, one gives clearly the details of the seating arrangements and includes the main dimensions. This portion of the drawing also indicates that, behind the rear seat squab, the trunk has a length of 52 in, and a normal width of 62 in, which is reduced to 42 in between the wheel arches. It accommodates a considerable quantity of luggage, even though the petrol tank projects into the compartment. Both front and rear seats are divided by central arm rests having a width of 6 in, but it does not appear that the driver's portion of the front seat can be adjusted separately.

The bonnet is downswept and the lamps are mounted in the front wings. At the rear, the wings accommodate the tail lamps. The capacious boot, already referred to, is accessible through a lid embracing the top and rear panels, and the spare wheel is carried beneath the boot floor. When open, all the doors are held at 60 deg by spring-loaded check straps. Another feature of the door equipment is that the windows are of the full drop type, with operation control by Beclawat Twelvex compensators.

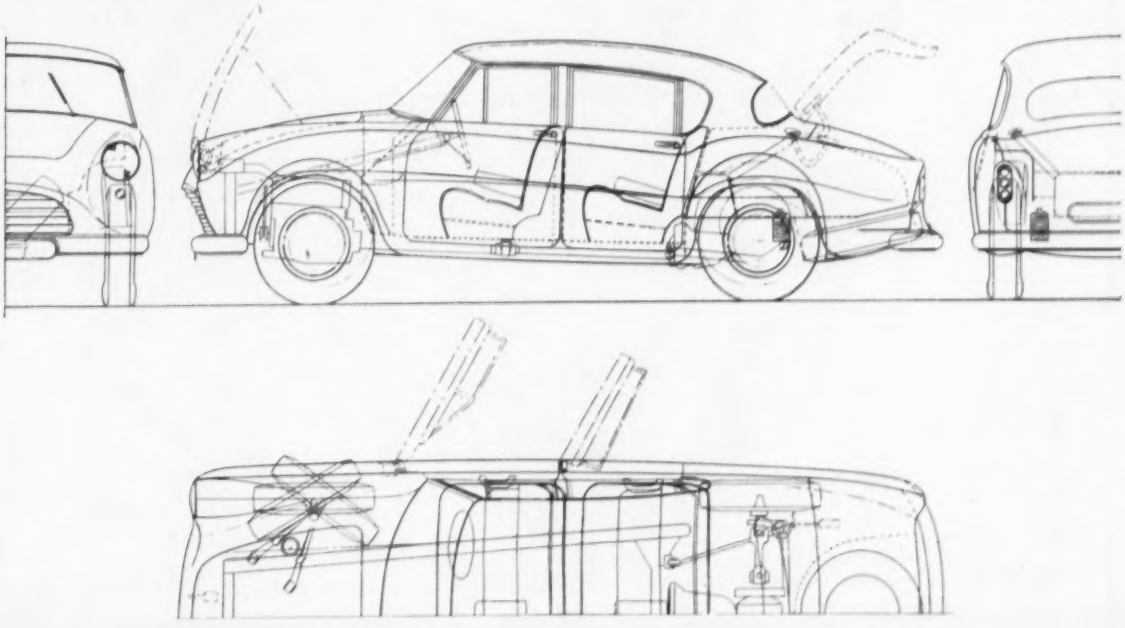


Among the other features illustrated on Sheet 2 of Eric J. Weaver's entry, the third prize winner in Competition No. 2, is a coloured drawing of the structure

The half length doors have chromium plated window frames, but this does not reduce the width of the central pillar, which is, if anything, of greater overall width than in normal all-steel construction. The door panels are locally depressed to accommodate the Schonitzer door handles. A depression in the boot lid houses the rear number plate.

This is intended to be an all-steel body, fully tooled and bolted to the chassis frame, an arrangement in which one component gives strength to another. Abridged details are given of the mechanical features of the chassis. The transmission includes a gearbox that forms a unit with the differential, an arrangement that does not appear to cause much inconvenience to the body engineer.

The second prize in this competition was not awarded, but Eric J. Weaver was awarded for a well rounded design, the third prize of £15 and the Company's medal. This competitor has arranged the power unit and radiator an appreciable distance forward of its usual position and thus there is considerable front overhang. However, this enables the passenger compartment to be kept well ahead of the rear wheel and also permits the incorporation of a capacious luggage boot. The maximum width of the boot



This design, which is called "Malcolm," by Geoffrey J. Clarke, gained first prize in Competition No. 2

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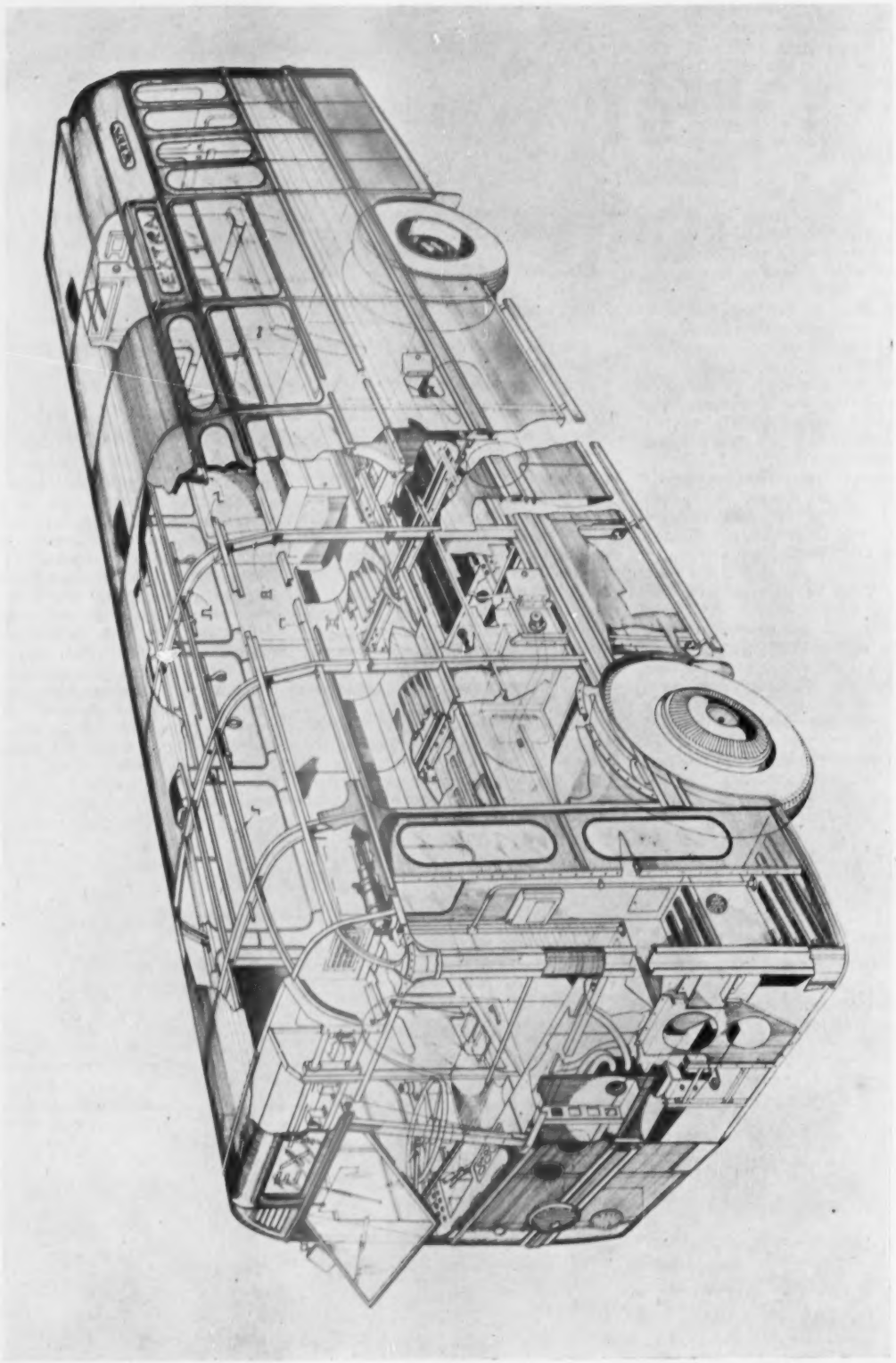


FIRST PRIZE, COMPETITION NO. 4

This design, by D. G. Thaxter, is called "The Bandit." The large exit doors at the rear are an interesting feature

is 54 in and it extends 37 in behind the rear wheel, its maximum depth being 18½ in. A flap fitted with spring-loaded hinges mounted just behind the back light, gives access to the luggage compartment.

As is usual, the petrol tank is behind the rear squab board; this allows the spare wheel to be mounted below the low boot floor. The doors are hinged on their forward pillars, and entry to the front seat appears to be reasonably easy. However, the fact that the rear seat is some distance forward of the rear wheel centre, leaves relatively little room for foot entrance between the seat cushion and the centre pillar, particularly as the rear doors are hinged on their forward edges.

Both doors are equipped with drop glasses. These windows conform to the continuous curve of the upper front pillars, cant rail and rear pillars, so large ventilating panels are necessary to give satisfactory parallel glass runs. There is no indication as to whether these triangular panels are of the ventilating type. In this design also, extensions of the front wings embrace the body side panels, which merge into the rear wings without any perceptible break.

Details of the all-steel body construction are given on a separate sheet which includes a well executed three-quarter front view of the body shell, clearly indicating how this shell—which is integral with the chassis members — incorporates the major chassis components. Diagonal cross bracing is used behind the rear seat squab board. This, no doubt, gives considerable rigidity to the rear end structure; the front bulkhead performs a similar function at the forward end. The floor pan is recessed to obtain a low overall height, and the lower body side members consist of double box sections in which the inner section, carrying the floor, has considerable depth.

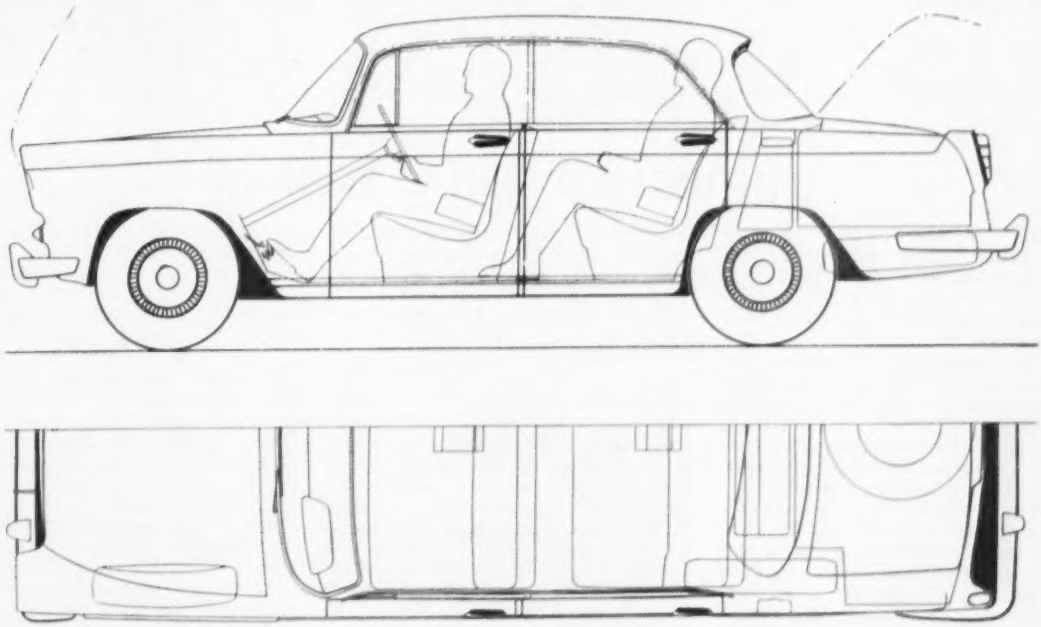
Competition No. 3

This class was restricted to students at any technical school or employees under the age of 21 in British workshops. It called for an outline drawing, in ink, of a four-door six-seater saloon, to a scale of 1½ in to the foot. An important requirement was that the seating arrangement should be clearly shown. The first prize of £20 was awarded to D. M. Morris, who submitted a well executed drawing featuring what is described as a pillarless body. In actual fact, this design is not of truly pillarless style as the term is generally recognized, for a half-pillar is used below the waist, and upon this the rear doors are hinged. There is no pillar above the waist and glass of the front door overlaps that of the rear door. This competitor obviously considers that the description of pillarless is applicable in the absence of the upper pillar.

Concerning the design itself, the main feature that attracts the eye is the forward inclination of the front bonnet panels. This treatment is also carried out on the front wings, which, as in all modern designs, are an essential feature of the bonnet construction. Similar treatment has been observed on some American cars and the only objection to it would appear to be that driving visibility is possibly more restricted than is the case with the well rounded style more commonly employed. There may, of course, be cases where low bonnet height with a conveniently high seating position will give adequate forward view, but as a rule, to obtain a good balance between the bonnet mass and that of the superstructure, the overall height of the body is kept low, with the seating position also as low as possible. This is a somewhat angular design although, since the severe lines of the front wing are repeated for the tail end of the rear wing, it is not objectionable but is, in fact, rather agreeable.

In accordance with what is now common practice, this entrant uses the curved screen and also a curved back light. Above this back light there is an outlet for foul air. This indicates that the designer is utilizing the space between inner and outer roof panels as an air duct, through which air is extracted from the passenger compartment. A fresh air inlet is provided at the rear end of the bonnet top. The bonnet is hinged at the front.

There is a special feature of the front door glasses that is worthy of comment. Obviously, with glasses that overlap above the lower central pillar, it is impossible for the forward glass, which extends beyond the front door shut line, to have a direct vertical drop. Therefore, this competitor specifies that these two front door glasses, when being lowered from the fully raised position, move forward to clear the door structure before dropping. Since this is only an outline drawing and details are not called for, it is not possible to see just how this motion is obtained. The situation is undoubtedly complicated by the fact that triangular panels are mounted at the forward ends of the door windows. Amongst other body features specified on the drawing are retractable arm rests, cowled instruments, a latex foam



Part of the first prize winning entry in Competition No. 3, by David M. Morris. This design is named "Geneva," and an unusual feature is the forward inclination of the front of the bonnet and wing panels

rubber cushion pad above the instruments, and a stainless steel rub strip extending along the lower panel between front and rear wheels.

A less attractive design, but one that contains features that are worthy of mention, was submitted by H. W. Mann, who was awarded second prize of £15. In execution, this drawing does not compare with that of the first prize winner. An important feature is the construction of the roof. The upper part of the screen pillar has a forward inclination and its lower end terminates a considerable distance behind the door hinge line. This, it is felt, would cause some inconvenience to the occupants when they enter or leave the front seats, for although the seat is low, the lower corners of the screen are almost bound to interfere with shoulder movement. Since this reverse inclination does not add to the good appearance of the roof, it is felt that such a feature does not merit inclusion.

In the wing design, the conventional follow-through wing is used, so that no distinction is made between wings and body panels. At the rear, a fin is introduced behind each wheel, apparently with the sole purpose of improving stability. A curved inclined screen is employed, and the rear portion of the roof consists entirely of a curved panel in transparent material, such as Perspex. This obviates the usual blind quarter panels. All four doors are hinged at their forward edges and, since both front and rear seats are low, it has been necessary to obtain sufficient leg room for the front seat occupants by setting the footboards forward on each side of the engine, and obviously a bulkhead or dash with a bowed central portion would be involved.

Competition No. 4

This competition was open to persons of British nationality, without age limit, and was for a general arrangement drawing, in ink, of a single deck stage carriage of metal construction, mounted on an underfloor engined chassis. The drawing was to be to a scale of $\frac{1}{4}$ in to the foot and the vehicle was to comply with the current Ministry of Transport regulations applicable to single deck vehicles. This body had to be capable of carrying in reasonable comfort the maximum possible number of seated and standing passengers during peak periods, and capable of seating not less than 24 passengers at any time. The general layout was to be suitable for one-man operation during non-peak periods.

The first prize of £75 and the Company's Medal was awarded to D. G. Thaxter, for a well thought-out design which was clearly shown both in the general arrangement drawings and in the three-quarter front view, which is reproduced in an accompanying illustration. Maximum accommodation for standing passengers is obtained by mounting double seats on the off side and single seats on the near side, while all the rear portion of the vehicle, where it is enclosed on one side by double doors, is available for standing passengers. This would promote easy operation during peak periods, for while it may be necessary for some of the standing passengers to pass down the centre gangway, those covering only a short distance would naturally stand just inside the rear doors.

The front entrance in the near side panel is opposite the driver's cab. This makes one-man operation feasible, since the passengers entering the vehicle could be issued with tickets as they pass the open-sided cab; they would have to leave by the rear doors.

Alternative seating plans are given and the drawings, which are on four sheets, are fully detailed. In the external appearance of the service bus, horizontal lines predominate. Relief is introduced on the side panels by double mouldings, completely embracing the vehicle, broken only by the head lamps and the rear lamp units. In addition to the normal side windows there are glazed lights above five of the windows on each side.

The three-quarter perspective view is extremely well done. It clearly indicates the disposition of body members and also much of the smaller detail work such as the accommodation of the mechanical unit that operates the entrance door. Although the preparation of this perspective view probably occupied as much time as all the detail work on the other three sheets, it cannot be too strongly emphasized that such a view is of considerable help to those assessing the merits of the design.

The second prize of £37 10s 0d and the Company's medal was awarded to C. P. Stephenson. This design, owing to its lack of prominent mouldings, is less outstanding than that of the first prize winner. The competitor also gives alternative seating plans. In one there are double seats with a wide central gangway, and in the alternative scheme double and treble seats, with a narrow gangway.

Light alloy construction is employed and a honeycomb stiffened floor has been adopted. Special attention has been devoted to the question of one-man operation. When only the driver is in complete control of the vehicle, a sliding door on the near side of his cab enables him to discharge the conductor's duties. This competitor also makes considerable use of perspective sketches to illustrate the method of construction that he adopts. These sketches illustrate the more intricate aspects of the construction. In the side framing, diagonal bracing plays an important part and undoubtedly would do much to prolong the effective life of the vehicle.

THE UNIFIED SCREW THREAD

THE conclusion that the Unified Screw Thread would ultimately supersede the Whitworth Thread was formally recorded by a special conference at British Standards House, when representatives of many branches of the engineering industries, the Service Departments, and the nationalized industries met under the chairmanship of Mr. H. A. R. Binney, director of the B.S.I., to review how far the Unified Thread has, in fact, been adopted in this country. The conference was called in response to many enquiries which B.S.I. had received from industrial producers and users of engineering equipment, from Government departments and others concerned, to know how far and how fast the change-over from the Whitworth Thread had progressed in the seven years since the signing of the "Declaration of Accord" between America, Britain and Canada, under which the three countries agreed to accept the Unified Thread.

It was recalled at the opening discussion at the conference that in the years immediately following the signing of the Accord several British Standards were developed for Unified bolts and nuts, screwing tackle and other details necessary for the implementation of the agreement. Reviewing progress from that point, the manufacturers of bolts and nuts said that in the early stages they had been unable to meet all the demands for Unified bolts and nuts, but recently the position had improved. The draft standard for black bolts and nuts in the "normal" series would soon be issued, and they now foresaw no serious difficulty in meeting any future demands likely to be made upon them.

Representatives from the motor, aircraft, oil and chemical industries, and from the Atomic Energy Authority, all said that they had adopted the Unified Screw Thread, and confirmed that, generally, availability now presented no problem. They were unanimous in stating that the change-over had not been nearly as inconvenient as they had thought it would be, and they were of the opinion that the difficulties involved could easily be exaggerated.

The indications all showed that the rate of the change-over had been considerably faster than might have been expected some four or five years ago; but, having regard to the advantages to be achieved by working to a single screw-thread system, it was agreed that the tempo should be quickened.

NEW PLANT AND TOOLS

Recent Developments in Production Equipment

TWO vertical rack generators, the VR 60 and the VR 72, are now available from W. E. Sykes Limited, Staines, Middlesex. The VR 60, which is shown in Fig. 1, will cut racks up to 60 in long and the VR 72 racks up to 72 in long. Both machines will cut racks with a maximum face width of 3 in and pitches within a range of approximately 5 D.P. to 64 D.P. Diametral, circular and module pitches can be generated, and either spur or helical teeth (right or left-hand) up to a maximum helix angle of 45 deg.

The teeth can be run out at both ends or may be terminated at any desired point, when by using a blocked-out cutter the end tooth spaces can be cut to full depth. Furthermore, the Sykes continuous rotary generating principle on which these machines operate, makes possible the production of intricate flat profiles in flat section.

All controls are conveniently grouped, and since the generating process relies more upon the accuracy of the cutter than on the skill of the operator, the most precise work can be performed rapidly and accurately by unskilled labour. Setting up is simple. There is a dial gauge fixture for truing the work and a large micrometer dial on the front of the infeed shaft shows the depth of cut. Adjustable limit switches automatically stop the machine when the required length has been cut, and since cutting can be effected in either direction of table traverse, it is only necessary to set the control to "reverse" to allow cutting to be resumed without returning the table to its starting point. Moreover, on the front of the machine table there is a vernier scale that enables the operator to "pitch in" accurately at any required point. Thus, when intermittent racks are being produced, minimum time is lost in traversing sections that do not have to be cut.

The rotary pinion-type cutter, which is normally of 4 in P.C.D., provides a series of cutting edges several times longer than could be provided by a rack time cutter. Cutter life is, therefore, materially prolonged. The cutter is mounted on a spindle that is reciprocated by a crank with a throw which is adjustable to suit the required face width. A simple adjustment governs the height of the cutter above the work table. Cutting is effected on the down stroke. Return stroke relief operates on the cutter head itself, with the work table, work and fixture remaining steady. As it reciprocates, the cutter slowly rotates in mesh with the work; thus, cutter and work are exact counterparts both in profile and accuracy.

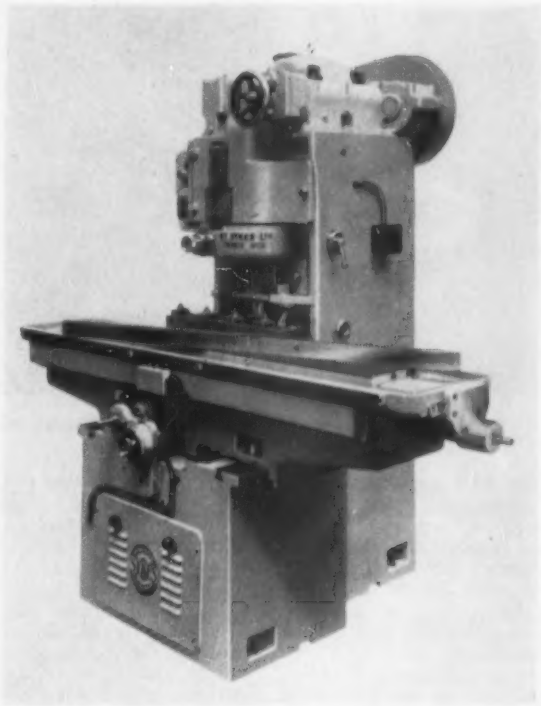


Fig. 1. VR 60 vertical rack generating machine
(W. E. Sykes Ltd.)

Racks of any length within the capacity of the machine can be generated with the same cutter, providing that the pitch, helix and pressure angles are the same. Moreover, by standardizing cutter pitch diameter, all diametral pitches can be generated without the necessity of altering the change gear ratio. Changeover from one system of pitch measurement to another is readily effected by means of the index change gears.

The cutter spindle guide is of hardened Meehanite, and the sleeve, which is provided with adjustable bearing blocks, is of ample dimensions. The cutter spindle sleeve, indexing wormwheel housing and cutter relief block form a single rigid unit. Cutter relief, which operates on the cutter head in a direction parallel to the axis of the indexing worm, entails only the movement of a light and rigid unit, so that there is sensitivity at high operating speeds. As the slides carrying the cutter head unit are mounted directly within the rigid box section machine casting, overhang is extremely small.

There are eight cutting speeds in the range 66 to 622 strokes per minute. Speed variations are effected by means of a two-speed motor, interchangeable pulleys, and a two-speed gearbox with lever control. Generating feeds are variable by means of change gears located in a compartment at the rear of the machine. With a 4 in P.C.D. cutter, the generating feeds can be varied from 0·0045 to 0·014 in.

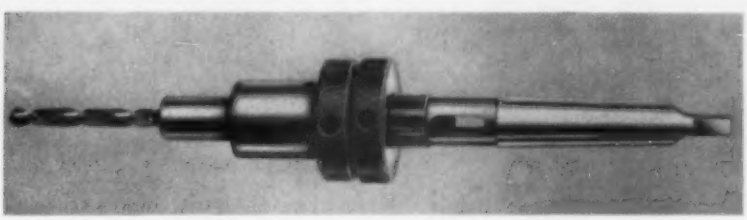


Fig. 2. Drill holder and setting gauge
(B.S.A. Tools Ltd.)

Drill holder and setting gauge

To facilitate the accurate drilling of holes to pre-set depths, B.S.A. Tools Ltd., Mackadown Lane, Kitts Green, Birmingham, 33, have developed the drill holder and setting gauge shown in Fig. 2. It can accommodate any size of drill, reamer, counterbore or tool with a standard morse taper shank. The component parts are a main body, a knurled locking ring and a combined bush and stop-nut.

To assemble, the drill is inserted

Fig. 3. Snyder connecting rod balancing machine
(Gaston E. Marbaix Ltd.)

into the holder, followed by the bush and stop-nut, which is threaded up the body an amount sufficient to give the required drilling depth, that is, the distance between the drill point and the lower face of the bush.

Normally, the holder, bush and stop-nut, and locking ring are threaded left-hand. This is a precautionary measure against inadvertent failure on the part of the operator to lock the bush in place. In such a case the bush would tend to work down the holder where normal right-hand rotation of the machine is employed, the drilling depth would, therefore, be decreased.

Connecting rod balancing machine

A new connecting rod precision balancing machine for heavy-duty and diesel engine connecting rods with centre distances from 7¼ to 12½ in has been developed by Snyder Tool and Engineering Co., Detroit, Michigan. This machine, which is illustrated in Fig. 3, is made up of three individual units: a milling machine with two opposing double-spindle heads; a console containing all the operating controls; and a precision weighing unit.

For balancing, the rod is first placed on the weighing unit. When this is done, part finder fingers on the machine are automatically set to within 0·001 in for the removal of the correct amount of stock from lugs provided on the piston and crankshaft ends of the forging. When the part finder fingers are set, the rod is manually removed from the weighing unit and placed in a fixture on the milling machine. Depression of a cycle button on the console then causes the fixture to retract between the milling heads, while simultaneously clamping the rod. Both heads then advance until the part finder fingers contact the ends of the rod. The heads are then locked in the correct milling position for removing the excess material from each end. The fixture feeds forward, first past a set of roughing cutters and then past a set of finishing cutters. The weighing operation for another rod is carried out during the milling operation. A 15 h.p. motor drives the head for the crankshaft end of the rod, and a 7½ h.p. motor drives the head for the piston end. All head and fixture movements are hydraulically controlled. Gaston E. Marbaix Ltd., Devonshire House, Vicarage Crescent, London, S.W.11, are the British agents for these machines.

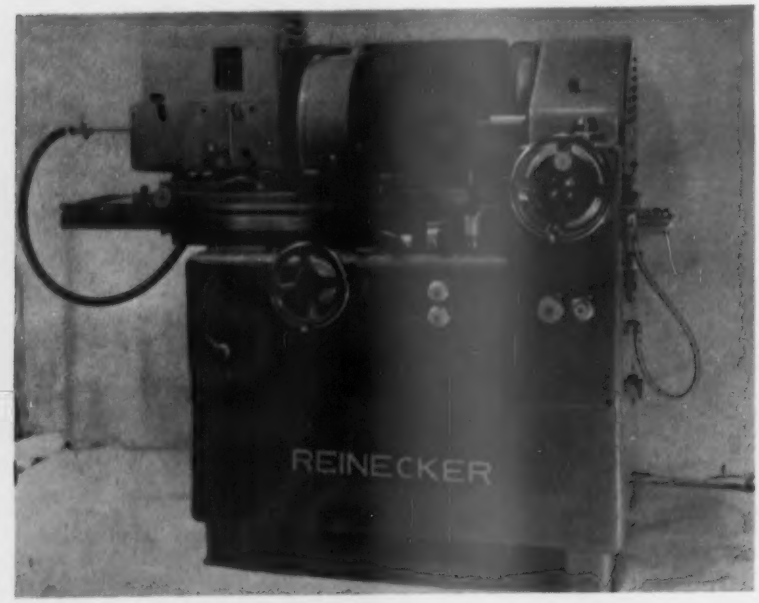


Fig. 4. Reinecker automatic internal grinding machine
(Stuart Davis Ltd.)

Automatic internal grinding machine

A new Reinecker automatic internal grinding machine, the J.S.O.A., is illustrated in Fig. 4. It is electro-hydraulically controlled and has a fully automatic operating cycle. The indirect sizing method is used for controlling size. Plain or taper holes, straight through or partially blind holes can be ground economically. Rapid approach of the table, automatic starting of workhead and coolant supply, followed by automatic switching of table feed to rough grinding, are effected by operating one starting lever.

When the bore being ground reaches the "rough" size, the table rapidly returns for automatic wheel dressing and compensation for wheel wear. Then the table feed automatically switches to grinding speed, and grinding continues until the finish size is reached.

Indirect sizing is effected by setting the diamond dresser through a manometer adjuster. Sizing can be carried out to the finest limits. Direct sizing by using plug gauges from the rear can also be used for through holes. A valuable feature of the machine is the face grinding attachment, which enables the face to be ground true to the bore. This attachment is automatically operated

The workpiece is held in a collet chuck, a magnetic chuck or a three-jaw chuck, whichever is the most convenient. Radii or internal profiles can be ground by using special attachments. High speed internal grinding spindles running up to 60,000 r.p.m., or high frequency grinding spindles for small holes are available. Stuart Davis Ltd., Much Park Street, Coventry, are the British agents for these machines.

BRITISH PLASTICS EXHIBITION

A Brief Survey of Some of the Features of Interest to the Motor Industry

ALL the earlier British Plastics Exhibitions had features of interest to automobile engineers; this year's Show was no exception. That progress has been made in the two years since the previous Show could be seen from the improvements that were evident among the exhibits, particularly of plastics bodies and components for cars and commercial vehicles. The finish of the plastics panels and of complete vehicles exhibited is generally markedly superior to that of models exhibited two years ago. So far, plastics bodywork has been used mainly for special applications; however, there are many other types of plastics components, such as gears and thrust washers, that are well established and widely used in the motor industry.

This car body was manufactured by Martin Plastics Ltd. It is made of Bakelite polyester resin and glass fibre

Car bodies and components

The advantages and disadvantages of polyester glass fibre panels and the methods of manufacture are, by now, well known. Briefly, the panels are strong and resistant to impact; blows that would dent or buckle sheet metal or splinter timber panels have little or no effect on the reinforced plastics materials. A substantial saving in weight can be obtained by the use of plastics, and local stiffening and strengthening is relatively easy. Unlike metal, the plastics panels are not subject to corrosion, and their sound-deadening and heat insulation properties are added advantages.

Raw materials used in the manufacture of these panels are expensive, but for production in small quantities, the saving in tooling costs in many instances more than offset this disadvantage. Moreover, highly skilled operators are not needed to do the lay-up of the materials, so the process is less costly than panel beating. The time required for the resin to set, or cure, generally varies between 30 min and 8 hr, according to the quantity of hardening agent added and the temperature.

A car body manufactured by Martin Plastics Ltd., Maidstone, was shown on the stand of Bakelite Ltd. This body is made of Bakelite polyester resin impregnated glass fibre. It is for mounting on the 1938-1954 range of Ford 8 and 10 h.p. chassis.

Other car bodies made from Bakelite material have been manufactured by W. Jacobs and Son Ltd., and Necolam Ltd., of Blyth. Jacobs bodies have been fitted to M.G. chassis and Necolam manufacture bodies for R.G.S. Automobile Components Ltd. Among the other exhibits on the stand of Bakelite Ltd. were the clear and tinted, rigid and flexible Vybak sheet for side screens and rear windows for the hoods of convertible cars.

At last year's Motor Show, the Jensen plastics bodied car attracted considerable attention. The bonnet lid, which extends over the wheels on each side of the vehicle, was shown on the stand of British Industrial Plastics Ltd. at the British Plastics Exhibition. This body, like that of the Martin vehicle, has a painted finish. Although the plastics materials themselves can be pigmented to save a painting operation, there are disadvantages associated with panels made in this way. To obtain a good finish in colour, it is necessary to incorporate a relatively thick layer of unreinforced, pigmented resin on the surface. If this surface is subsequently damaged during service, starring sometimes occurs and this makes it difficult to restore the good finish. This trouble is not experienced when the surface layer of resin is thinner and is painted. An attractive alternative is to use a pigmented resin and to lay-up in the normal manner, that is, without the thick layer of unreinforced resin on the surface, and to apply a paint finish on top. This has the advantage that should the paint be scratched, the damage is not readily visible because the colour of the plastics underneath it is similar.

A good finish had been obtained on the bonnet lid that was exhibited. It was stated on the stand that neither sanding nor polishing was necessary after the component had been removed from the mould. Inside the lid, there

The front end panel of the Jensen plastics bodied car was demonstrated with one half painted and the other unpainted to show the surface finish

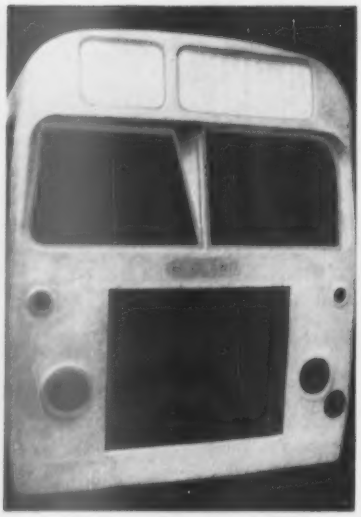
Reinforced plastics stiffeners are moulded on to the underside of the front end panel of the Jensen car before the lay-up has set

were stiffeners that had been preformed and moulded-in while the lay-up was still wet. The material, of course, can be drilled, punched, tapped and riveted. In general, chopped strand mat was used for the lay-up, but there were certain exceptions, notably small components that are more easily moulded with cloth.

Tufnol is employed extensively in the motor industry for a wide variety of components, ranging from cam heels in distributors to timing gear wheels. The material has a number of advantages that make it particularly suitable for these and certain other applications. It is not adversely affected by petrol, oil or atmospheric conditions, and is light, strong and wears well. In electrical applications, the material is useful because of its insulation properties. It can be machined more easily than metal and can be punched accurately and economically. Tufnol is also used in bearings and under certain conditions little or no lubrication is required. In other circumstances, water is effective as a lubricant.

The material is available in sheets approximately 46 in square, and up to 9 in thick. It can also be supplied in 46 in long strips in various widths suitable for punching. For bearings and other applications, tubes made of Tufnol can be supplied. They are 46 in long and their cross sectional dimensions are up to 4 in. Rods, 46 in long and up to 2 in diameter, are also available, and special shapes can be moulded.

Common applications in the motor industry are thrust washers for king pins, bushes for control rod guides, body mounting blocks, facia panels, carburettor-flange washers, couplings for dynamo and magneto drives, commutator cores, slider bushes and damper pistons for motor cycle front forks, and fuel pump valve discs. In each application, co-operation between the designers and the material suppliers is most desirable. Co-operation should begin at the earliest possible stage in design so that the material can be used to best advantage.



Front end panelling used experimentally on the Birmingham and Midland Motor Omnibus Co. Ltd's single deck bus

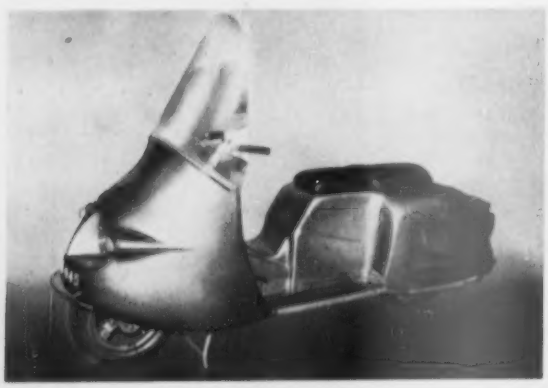
It is necessary to ensure that the material is used in its most suitable form in each particular application. Failures have been known to occur as a result of the use of the wrong type of material. For example, gear teeth have been known to strip because the components were machined from tube. This is not surprising, since the fabric reinforcement in tube is generally wrapped round and, of course, the teeth shear on a plane between the layers of wrapped fabric. Gears should be made from sheet material in which the fabric layers are parallel to the plane of the sheet.

On the stand of Fibreglass Ltd., there were many items of interest to motor manufacturers. Among the exhibits was a one-piece front-end panel for the Birmingham and Midland Motor Omnibus Co. Ltd.'s single deck bus. The moulding includes part of the front of the roof panel as well as the screen pillars, and front panel with its cut-out for the radiator. In the production of this component the wet lay-up process was used and the materials employed were Fibreglass chopped strand mat and polyester resin. A number of manufacturers are experimenting with plastics materials for front and rear ends of buses, because the panelling in these areas is particularly liable to suffer damage. By the use of plastics material, fewer repairs may be necessary and those repairs that are required may be less expensive than if metal panels were used.

Another exhibit on the Fibreglass stand was the Harper Scootomobile, made by Harper Aircraft Co. Ltd. Chopped strand mat was also used in the production of the panelling that covers the mechanical components of this motor scooter. Pigmented resin is employed but a paint finish of a similar colour is applied. Thus, in the event of the paint being scratched, the damage will be scarcely noticeable. Because of the light weight of this material, it has much to commend it for application to motor scooters. Its impact resistance is also an advantage because light-weight vehicles are particularly liable to suffer damage, since most are relatively easily knocked over when parked.

Tubes for the manufacture of bracing structures required to conform with complex shapes are also made from Fibreglass reinforced plastics. The tubes can be readily sawn into the lengths necessary to make the structures. Their ends can be appropriately shaped to conform with the profile of the components they are required to brace; alternatively, slots can be cut in the ends to receive gusset plates to form the joints of the structure. Accuracy in cutting the lengths is not essential since adjustment can be made simply by moving the tubes axially to vary the depth of engagement of the plates in the slots.

After adjustment has been effected, the joints are made good by the use of a glass-reinforced putty, consisting of approximately 40 per cent polyester or epoxy resin, 30 per cent Kaolin, or similar filler, and 30 per cent $\frac{1}{8}$ in chopped glass strand. This mixture is



Reinforced plastics panelling on the Harper Scootomobile. This material can be readily moulded into complex shapes, is light and has good impact resistance

Access to the engine and most of the other mechanical components of the Harper Scootomobile is gained by lifting the whole of the rear end panelling

formulated so as to set at room temperature. An alternative method of bracing the joints is the use of a wet, resinated glass fabric tape, which is wound round the joints like a bandage. The advantages claimed for this form of bracing structure are: time saving in manufacture, light weight, dimensional stability, resistance to adverse climatic conditions, rigidity and negligible moisture absorption. The manufacturers are Ogden Smiths and Hussey Ltd.

Resins

A recent development of Shell Chemicals Ltd. is the CHC Vapour-Phase Corrosion Inhibitor. This is a white crystalline solid, which is very soluble in water, methyl, ethyl alcohols and methylated spirit. The compound volatilizes slowly at atmospheric temperatures. Since many carbonates and organic bases have anti-corrosion properties and the new compound is a carbonate of an organic base, the protective action is probably of a two-fold nature. Experiments have shown that when CHC is introduced into a closed package, vapour is produced immediately and diffuses rapidly throughout the contents. The vapour pressure is great enough to ensure that adequate concentration of vapour is built up with a minimum of delay. If the package is subsequently opened and then sealed again, an effective concentration of vapour quickly re-develops, provided that some of the inhibitor is still present in solid form.

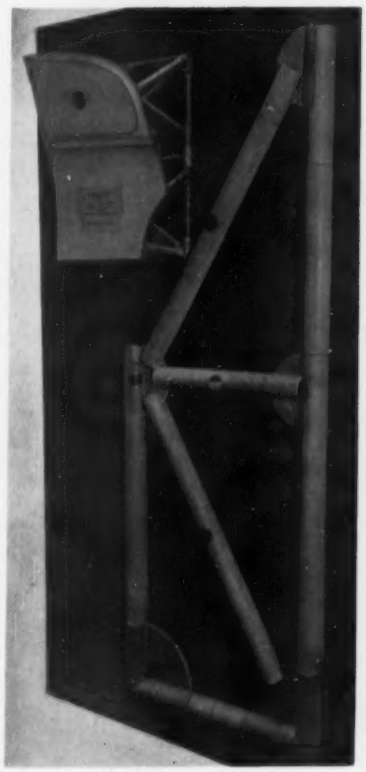
It is stated that the compound is as effective when it is at a distance of 30 in as at 1 in from the component. The vapour is more active than solid CHC when in contact with metal. This inhibitor almost completely prevents further corrosion of rusted mild steel or cast iron components. Moreover, it is effective when water vapour, condensation or water droplets that contain salt are present. It should be useful in packages containing components for export.

The Epikote resins, manufactured by Shell Chemicals Ltd., are noted for their high strength and resistance to chemical attack. Moreover, at higher temperatures they retain their properties better than most other materials of this type. This resin is, therefore, used in applications where good quality is a paramount requirement. For example, it has been used in the manufacture of bodies for racing cars because, it is claimed, the saving in weight obtained is worth the extra cost of the material. Tanks for carrying certain chemicals have also been made with Epikote resin, because of the resistance of this material to chemical attack.

Another application for Epikote resins is in paints. They have been used experimentally in the United States for primers for automobile bodies. Among the advantages of paints of this type are their ability to keep out water and their good adhesion. These manufacturers also supply Ketane solvents for cellulose coverings for components such as door handles and steering wheels.

Certain of the well known Rockite phenolic thermo-setting moulding materials are now offered in extruded form by British Resin Products Ltd. Close tolerances are maintained throughout the manufacture of the extrusions, which require no finishing operations apart from cutting to length. They can, however, be readily machined if necessary. These Rockite Rigid Extrusions are heat resistant and have a durable high-gloss finish. Their ultimate tensile strength is 7,000-8,000 lb/in^2, they have an impact strength of 0·17-0·19 ft-lb, and they are available in a variety of colours.

Cellobond brake lining resins are also supplied by British Resin Products Ltd. This group of materials comprises binder resins and friction dusts. Cellobond cashew resins in solution are used for impregnating woven asbestos linings and as binders in the wet-mix process. In powder form, these resins are employed as binders and friction dusts in the manufacture of moulded brake linings by the dry-mix process. These materials are said to give good anti-fade characteristics.



A demonstration panel on which are mounted plastics bracing structures

Among the exhibits on the stand of Scott Bader and Co. Ltd., Wellingborough, Northamptonshire, were Crystic resins made up in the form of the Crystic Lock-Nut Cement. This material is offered for use in an inexpensive and reliable method of preventing bolts, nuts and studs from working loose under the influence of vibration. It is applied during assembly of the threaded components and can be made to set at room or more elevated temperatures. The torque capacity obtainable is considerable, and can be controlled by changing the amount of plasticizer in the material. Crystic Lock-Nut Cement, in addition to locking the components, provides an extremely effective oil seal, and when fully set it is resistant to oils and other solvents. Rust formation is also prevented.

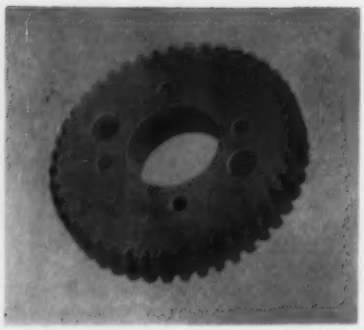
For hot locking, the cement is prepared by mixing 100 parts, by weight of Crystic Lock Nut base with three parts of Crystic activator and 25 parts of Crystic plasticizer. Care must be taken to disperse thoroughly the activator. At normal room temperature, this activated cement is stable for ten to fourteen days.

One or both the threaded components are dipped in the cement; alternatively, brush or spray application may be adopted. Then the components must be assembled immediately, otherwise the cement drains away. To set the cement, the assembly is stoved at about 120 deg C. The time needed for this operation depends on the size of the threaded parts and the rate of heat transfer, but for most purposes at least 30 min. should be allowed. However, small bolts attached to relatively light sections of metal can be fully set within 3 min. Provided that the stoving temperature is not higher than 150 deg C, no harm is done by over-stoving.

If cold locking is required, the same cement is used, but 0·5-1·0 parts of Crystic Accelerator are thoroughly mixed in. After the accelerator has been added, the useful life of this mixture is approximately one hour. It is therefore important to prepare only sufficient cement for about forty minutes' work. The method of application of the cement is the same as already described. At room temperature, locking is complete within two or three hours and the torque resistance obtained is equal to that obtained by heat locking.

In the single mould method of making large polyester glass fibre mouldings, it is in most instances necessary to use resin which has a high apparent viscosity, but when stirred or otherwise subjected to mechanical agitation immediately becomes less viscous. This property is known as *thixotropy*. With resins that are not sufficiently thixotropic, resin drainage on large vertical surfaces may be considerable, both when preparing the gel-coat and when laying-up the glass mat or cloth. Higher viscosity resin is unsatisfactory, since it is difficult to apply, does not thoroughly impregnate the glass fibre and tends to trap air.

Crystic Pregel thixotropic resins have been developed to meet the



A Tufnol quiet-running gear wheel for a mag-dynamo

requirements for laying-up on vertical surfaces. This material can be added to Crystic and Marco polyester resins to obtain the necessary degree of thixotropy. In many instances, the use of a material of this type is essential to obtain satisfactory results in the laying-up process.

The first thixotropic polyester resin introduced by Scott Bader was the Crystic Pregel 15. It was put on the market in 1953. This material has a high degree of true thixotropy but is unsuitable for certain applications because of its dark colour. Consequently, the lighter coloured Crystic Pregel 17 has been developed.

On large vertical lay-ups, the following mixture should be used for the gel-coat: 50 parts by weight of Crystic or Marco resin, 50 parts of Crystic Pregel 17, 4 parts of Catalyst Paste H, 4 parts of Accelerator E, together with the necessary amount of pigment or pigment paste, if required. On an inclined, as distinct from vertical, surface, the proportion of Pregel 17 should be reduced. In some applications the addition of as little as 15 parts of Pregel 17 to 85 parts of normal resin is adequate.

It may also be desirable to use Pregel 17 when impregnating glass mat or glass cloth on a vertical or nearly vertical surface. The requirements are that the glass fibre must be thoroughly wetted and at the same time the resin must not run down during the curing process. To meet these requirements, the following formulation is recommended: 75 parts by weight of Crystic or Marco resin, 25 parts of Crystic Pregel 17, 4 parts of Catalyst Paste H, 0·5-4·0 parts of Accelerator E, depending on the setting time required. Whenever powdered fillers are incorporated, they must be thoroughly dispersed in the normal resin before the addition of the Pregel.

Crystal Pregel 15 can be used in place of Pregel 17 in either of these two mixtures. This material is best for applications where a very high degree of thixotropy is required and where colour is not important. It tends to retard the setting time of the resin mixture, but this effect is least pronounced when it is used in conjunction with Crystic 189. Pregel 17 does not retard the setting time of resin to any extent and can, therefore, be used with any Crystic or Marco resin. However, the amount of Pregel used in any formulation should be kept to an absolute minimum and should be sufficient only to overcome serious resin drainage. The formulations that have been given here should be regarded only as approximate indications of the proportions required. In many instances, fabricators may find it desirable to modify these mixtures to suit different applications. Crystic Pregel 15 has a useful life of about three months, provided the storage temperature does not exceed about 20 deg C. The storage life of Pregel 17 at this temperature is about six months.

Release agents

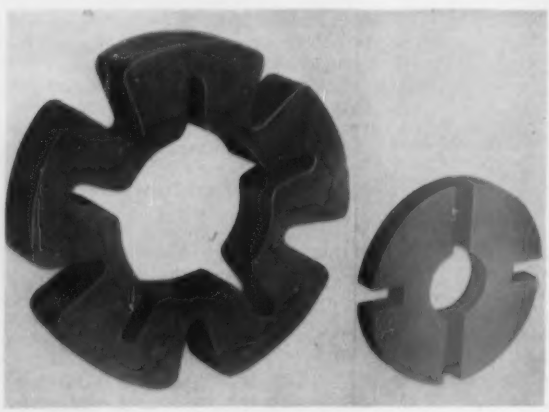
The choice of the most suitable release agent is of considerable importance, particularly in the production of glass fibre reinforced laminates and mouldings. There is no universal, general purpose release agent. Each of those available has advantages and disadvantages, and should be chosen to suit the shape, size and type of mould used, the final surface finish

Tufnol forms the electrical insulation in this commutator for a Lucas dynamo

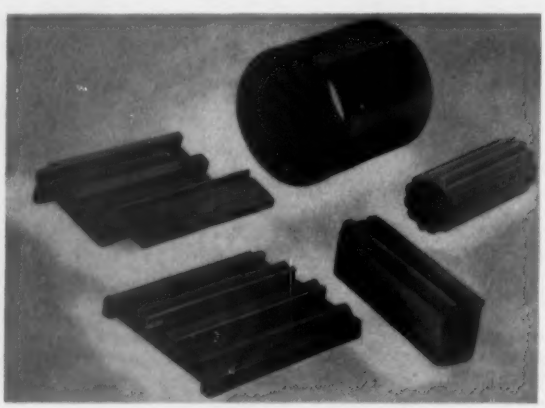
required and the rate at which the mouldings have to be produced.

In rubber bag moulding, sheet material, such as Cellophane polyvinyl alcohol film, cellulose acetate or polythene are used as separating agents. For other applications, a variety of release agents are available. Among these is the Crystic release agent No. 1, which is a form of quick-drying cellulose acetate solution. It is for use on moulds of timber, plaster or other porous materials. If it is used on metal or polyester/glass laminated moulds, care must be taken to ensure that all the solvent has been removed before the lay-up operation. This may involve drying the film of release agent under warm conditions, for example, with a fan blowing hot air. Otherwise, it may be necessary to leave the coated mould for at least 24 hours before lamination begins. Failure to do this may result in the loss of a mould due to sticking.

Another release agent is Crystic No. 2. This is a quick-drying film of polyvinyl alcohol solution. At least two coats should be applied, preferably by spray, but since each film dries almost instantaneously, a complete mould can be prepared rapidly. Materials of this type can be used to best advantage on moulds made of metal or polyester/glass laminates.



These Tufnol couplings are employed to absorb shock in dynamo and magneto drives



A selection of Rockite phenolic and urea extrusions made by British Resin Products Ltd.

They are in many instances employed as a secondary and expendable film on a mould surface that has already been treated with Carnauba Wax P-Y or Dribrite E.80.

Dribite E.80 is a wax emulsion and can be used on any type of metal surface. In making car bodies, boat hulls and similar large mouldings, the E.80 material is used for the initial treatment of the mould. When this is dry, a film of No. 1 or No. 2 preparation is sprayed on as a secondary release agent.

For metal moulds, Carnauba Wax P-Y gives good results, particularly when the hot curing process is used with matched die moulds. This release agent should be applied hot and great care must be taken to cover every part of the mould surface, while at the same time using as little of the material as possible. Therefore, it is advisable in many instances to rub the mould surface with a clean rag after the wax application. In this way, any excess wax is removed.

If the length of time required for the agent to dry is not important, polyvinyl alcohol solution can be used. Scott Bader supply this in concentrated form; before use it should be diluted with about four times its volume of water. Excellent surface finish and gloss are obtainable when this solution is employed. In addition, the initial release movement of the lay-up in the mould is easily effected. It can be made even easier if water or methanol is used to lubricate the interface when the resin is set. Polyvinyl alcohol solution should always be used on glass unless a smooth matt finish is required, when Crystic Release Agent No. 2 is recommended.

Many of the domestic wax polishes contain solvents, such as white spirit, which do not readily dry out when the polish is used as a mould release agent. This sometimes results in the laminate having a tacky surface. In addition, certain soft waxes are incorporated in some of the polishes and these are readily attacked by the styrene in the polyester resin. This causes serious mould sticking. When a gel-coat is applied to a mould surface treated with this type of material, the soft waxes sometimes dissolve in the resin to such an extent that adhesion between the gel-coat and subsequent layers of laminate is considerably impaired.

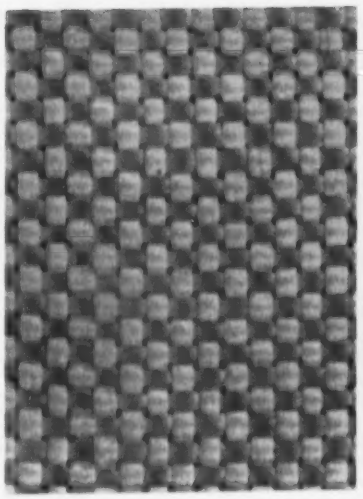
When mouldings have to be finished by painting, it is essential that all traces of release agent should be removed from the surface of the moulding. If any of the wax release agents have been used, this may be difficult even with efficient degreasing agents. It is, therefore, recommended that Crystic Release Agent No. 2 should be applied as a secondary film over waxed mould surfaces. All traces of the No. 2 preparation can be removed simply by washing down in plenty of warm water.

Glass fibre cloths and mats

Among the manufacturers who exhibited glass yarns, rovings, cloths, mats and cords for use in the preparation of laminates was Glass Yarns and Deeside Fabrics Ltd. Roving is a bundle of any number of slivers placed together in parallel and set up in a pack of suitable weight or shape for the customer's requirements. It is a convenient way of packaging sliver for transport and further processing by the reinforced-plastics industry. These manufacturers supply rovings either Volanized, as standard, or Silane treated. The Silane treatment obviates the need for post-finishing operations before impregnation with resin. Silane treated rovings, made up into finished cloth, give over 90 per cent wet strength retention, as determined by the A.S.T.M. two-hour boil test.

Yarns are slivers suitably twisted and doubled together for weaving or for the manufacture of tapes, braids, etc. All Deeglass yarns are supplied pre-Silane treated. This means that the weaver does not have to de-size or carry out any post finishing operation on the cloth. These yarns also give over 90 per cent wet strength retention. Deeglass can also be supplied in the form of chopped strand mat, chopped fibre cloth, mat and roving, and the materials can be pre-impregnated with resin.

Turner Bros. Asbestos Ltd. of Rochdale are now producing a woven roving. This type of weave is shown in an accompanying illustration, and it has a number of advantages. The cloth is woven from continuous filament roving without twist. This represents an important technical development,



A full-size illustration of a woven roving cloth

since it improves the stiffness and strength of the finished product. If the filament is twisted, there is a tendency for it to straighten out when the laminated components are subjected to load, and this reduces the strength and stiffness of the component. Another advantage of the weave is that the finished laminate can be produced with a high content of glass. This is because the glass fibres pack together better when they are not twisted. The weave is relatively flexible so that the material can be draped over curved surfaces more readily than most other cloths.

Where a smooth surface finish is required, the eight-shaft satin weave type of cloth is suitable. In this cloth the yarn, instead of being woven over one and under one alternately, is woven over eight and under one to give the smooth satin finsh. The plain weave type of cloth is used principally in the aircraft industry for radomes, since the open weave of the cloth enables an excellent inter-laminar resin bond to be obtained. All the continuous filament glass fibre materials, comprising yarns, broad fabrics, narrow tapes, rovings, chopped rovings, sleevings and cords produced by this manufacturer are marketed under the trade name of Duraglas.

DIESEL FUEL

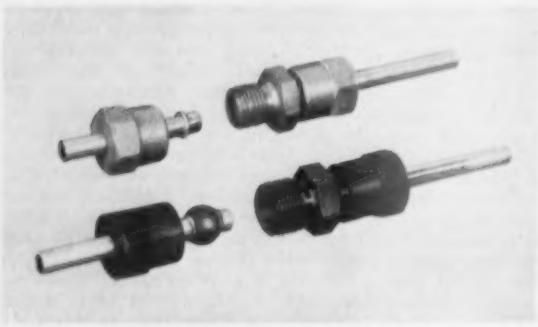
ACCORDING to Caterpillar Tractor Co., materials that were for many years looked upon as refinery residues are now being increasingly used in the production of standard diesel fuels. Called "cracked distillates" or "recycle stocks," they were originally considered as refinery residue from the production of high-octane petrols. Later, they were combined with higher grade "straight-run distillates" and used as diesel fuel. Now, studies by the Caterpillar Research Department at Peoria, indicate that, if certain requirements are met, the cracked distillates can be used in Cat diesel engines without harm to the engine.

The investigations covered four problems. They were: (1) the formation of gummy conditions in storage; (2) flow and spray characteristics necessary for use in high pressure diesel injection systems; (3) cetane numbers high enough to permit proper combustion; and (4) careful attention to lubricating oil and oil changes. From the first, Cat engines have been designed to use West Coast crudes with a low cetane number, and it is now found that the fuel prepared from recycle stocks generally meets required standards for Cat engines or can easily be made suitable by using additives.

HEADLAND PIPE COUPLINGS

"Hardball" and "Single Rib" Types for High-pressure Duties

DESIGNED specifically to meet the exacting requirements of high-pressure hydraulic or compressed air systems for aircraft, the "Hardball" coupling is characterized by the use of a hollow ball of hardened steel as the pipe nipple. This ball is permanently secured to the pipe by an upsetting operation which forms a rib on each side of the ball. Thus the need for soldering, brazing or welding, and the consequent possibility of corrosion, weld decay, or other undesirable weakening of the pipe, is eliminated. Although it bears a superficial resemblance to the conventional compression joint it should not be confused with that type, since the ball is not compressed on to the surface of the pipe. The ball makes the joint by line contacts with coned seatings in the union and the coupling nut. Only relatively low torque values are necessary to secure a pressure-tight joint which can be dismantled and reassembled without injury to the mating surfaces.



Headland high-pressure pipe couplings

The "Hardball" coupling is intended for light-gauge piping systems operating at pressures up to 4,000 lb/in² and capable of withstanding ultimate pressures up to 10,000 lb/in². For such duty, piping in stainless steel, D.T.D.743 specification, is recommended in the following gauges:—

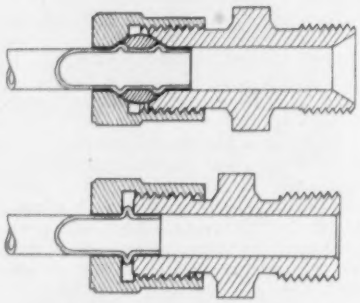
$\frac{1}{16}$ in	outside diameter	24 S.W.G.
$\frac{1}{4}$ in	" "	24 S.W.G.
$\frac{3}{8}$ in	" "	22 S.W.G.
$\frac{1}{2}$ in	" "	20 S.W.G.

Other piping, either ferrous or non-ferrous, may be used as required. The usual range of fittings, including straight couplings, male or female stud couplings, elbows, tees, and reducers, is available in light-alloy, brass, steel or stainless steel. Light-alloy to specification D.T.D.423 is the standard material for fittings and coupling nuts in order to keep the weight as low as is practicable, and is satisfactory for the pressures referred to earlier. The parts are anodized black for identification purposes, and also to prevent corrosion. Steel fittings, other than stainless steel, are cadmium plated. The standard material for the pipe ball is En 31, heat-treated. Standard screw threads for the fittings are related to the piping sizes as follows:—

$\frac{1}{16}$ in	outside diameter	$\frac{1}{8}$ in B.S.P.
$\frac{1}{4}$ in	" "	0·60 in o/d 19 t.p.i.
$\frac{3}{8}$ in	" "	$\frac{1}{2}$ in B.S.P.
$\frac{1}{2}$ in	" "	$\frac{3}{4}$ in B.S.P.

The two ribs securing the ball to the tube are formed simultaneously by means of a portable tool, which is held either in a bench vice or, by the addition of a tubular shank, in a pipe vice. Two models are available; one for piping up to $\frac{1}{4}$ in diameter and the other for $\frac{3}{8}$ in and $\frac{1}{2}$ in diameter piping.

To fit the ball, the procedure is first to cut the pipe to length, square the end and remove any burrs. After sliding on the coupling nut, the pipe is inserted between vertically slidable pipe jaws of appropriate size on the left of the tool and gripped finger-tight by turning the upper clamp screw by its knurled flange, the lower jaw being pre-set to correct height by a screwed adjuster and locked in position. The hardened ball is fitted on the pipe and a forked distance gauge is placed over the ball. This determines the initial distance between the face of the jaws and the face of the recessed die in the end of the horizontal forming screw. When the forming screw is turned by its knurled flange until the gauge is loosely held between the jaws and the die, the appropriate length of pipe protrudes from the jaws and the ball is correctly positioned. In the forming screw is a co-axial screwed spindle carrying a mandrel, which is advanced into the bore of the pipe to ensure alignment and to support the pipe internally.

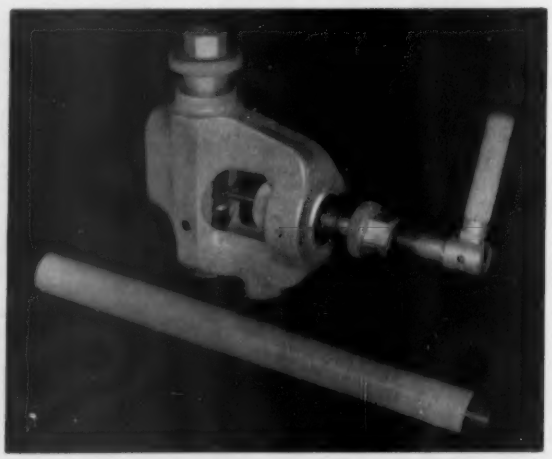


Sections of assembled "Hardball" and "Single Rib" couplings

With all items in position, the pipe is then securely clamped by tightening the jaws with a wrench, the distance gauge is withdrawn, and the forming screw is advanced with a wrench until the knurled flange abuts the body of the tool. This completes the ribbing operation and, after slackening off the load on the clamp screw, the mandrel and the die are retracted and the jaws opened to permit the withdrawal of the pipe with the ball in position and ready for service.

Intended for use under less exacting conditions than those for which the "Hardball" coupling was designed, the "Single Rib" coupling offers similar advantages with a simpler and cheaper construction. As the name implies, the tube is upset to form a single rib or flange, which makes a joint with plane surfaces on the fitting and the coupling nut. With the light alloy fittings, its weight is extremely low.

The couplings are manufactured by T. P. Headland, Ltd., Westminster Bridge Road, London, S.E.1.



Portable tool for pipe ribbing operation

EXHAUST GAS ANALYSIS

The Application of an Iodine Pentoxide Method in Petrol Engine Research

A. L. Wachal, Dipl.Ing., A.M.I.Mech.E., M.Inst.Pet.

SINCE the end of the war, operating costs of motor cars have been rising steadily and it is of great importance both to manufacturers and car users that all methods likely to improve operating economy be investigated. One of the characteristics which still offer scope for appreciable improvement in the modern petrol engine is fuel combustion efficiency. Unlike diesels, spark ignition engines do not normally produce smoky exhaust when the borderline of unsatisfactory combustion is reached. This may be regarded as a mixed blessing since it masks design and operational shortcomings.

One of the most important of the factors contributing to the heat losses caused by incomplete combustion of fuel in a petrol engine is the mal-distribution of air and fuel among its cylinders. If every cylinder of a multi-cylinder engine were supplied with a homogeneous combustible mixture of approximately 15 : 1 air/fuel ratio, there would be practically no heat losses due to incomplete combustion of fuel. If, however, because of imperfect formation and distribution of the air-fuel mixture, one cylinder received a 9 : 1 instead of a 15 : 1 air/fuel ratio, about 50 per cent of the fuel heat value would be carried away from this cylinder to the exhaust pipe in the form of objectionable partial combustion products. This example, which may well represent a real case in the production type multi-cylinder engine, stresses the importance of mixture uniformity on the overall fuel economy. The mal-distribution and its effect on the efficiency of the fuel combustion process are clearly reflected in the exhaust gas composition; hence the gas analysis is a very important tool in the study of petrol engine fuel economy.

With commercial fuels the main constituents encountered in petrol engine exhaust gases are:—

(1) Nitrogen and some unutilized oxygen from the air.
(2) Carbon dioxide and water as products of complete oxidation of the hydrocarbons.
(3) Carbon monoxide and hydrogen as principal products of incomplete oxidation of the hydrocarbons.

These gases amount to at least 99·5 per cent of the exhaust gases. The balance is composed of methane and some higher hydrocarbons; aldehydes, alcohols and organic acids originating from partial oxidation of the hydrocarbons; compounds derived from oxidation and inter-reaction of fuel additives such as ethyl fluid, and from impurities such as sulphur and also nitrogen oxides.

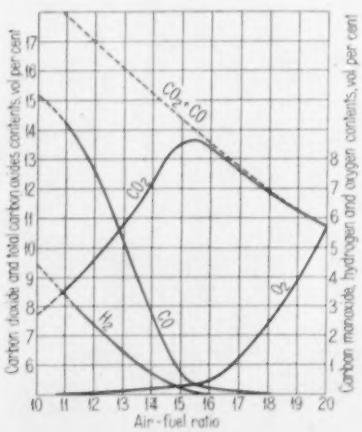


Fig. 1. Effect of air/fuel ratio on engine exhaust gas composition. Fuel:—technical iso-octane

Although these minor constituents may be of great importance in studying other aspects of engine performance such as wear, corrosion, combustion chamber deposits, etc., they can be disregarded in the calculation of engine air/fuel ratio and combustion efficiency. It is interesting that the concentrations of methane and higher hydrocarbons appear to be quite independent of mixture strength, and are seemingly unrelated to any other exhaust gas constituent.[1,2] They may also be quite negligible in a well maintained engine, even under rich mixture operation. This suggests that at least part of this invariably small proportion of free hydrocarbons in an engine exhaust is derived from thermal decomposition of lubricating oil rather than from the fuel.

For the further consideration of petrol engine fuel economy dry exhaust gas will thus be regarded as composed only of nitrogen, oxygen, carbon dioxide, carbon monoxide and hydrogen. There seems to be no advantage in the inclusion of combustion water in the exhaust gas analysis, and reporting results on a dry basis represents a considerable simplification in the analytical procedure.

Fig. 1 shows the composition of the dry exhaust gas from a C.F.R. spark ignition engine as it varies with air/fuel ratio. The fuel used was technical iso-octane with a carbon/hydrogen ration of 5·3 : 1. The nitrogen content, which may be obtained by difference from 100 after all the other constituents are added together, is of little significance in further considerations and for that reason is omitted from this graph.

Carbon dioxide, replaced by carbon monoxide at rich mixtures, is the next largest constituent of engine exhaust gas. Its concentration varies from approximately 8 to 14 per cent and can have the same value for two different air/fuel ratios. Hence, the mixture strength cannot be identified by the carbon dioxide content only. Carbon monoxide and hydrogen, on the other hand, are present in appreciable quantities only under rich mixture conditions; at air/fuel ratios above 14 : 1 the concentrations are too low for easy assessment on a volumetric basis, or to affect sufficiently the physical properties of exhaust gas in automatic analysers. It is thus quite understandable that Dilworth[3] and others found that instruments actuated by thermal conductivity or other physical properties of fuel combustion products showed practically no response when the mixture was leaner than 14 : 1. To cover the range of air/fuel ratios encountered in petrol engine practice, the quantitative determination of at least two fuel combustion products, for example, carbon monoxide and dioxide would normally be necessary. Orsat type analysers are usually provided for this requirement. However, the determination of fuel combustion products other than carbon dioxide in the Orsat apparatus is slow and laborious and only fully reliable if carried out by an experienced operator. Some

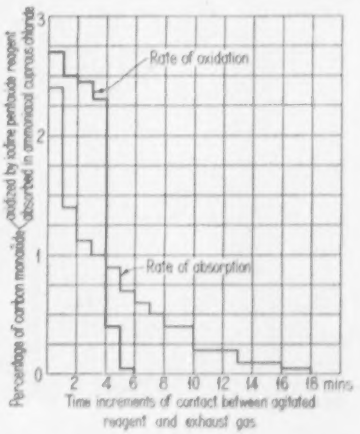

Percentage of carbon monoxide oxidized by iodine pentoxide reagent absorbed in ammoniacal cuprous chloride
Rate of oxidation
Rate of absorption
Time increments of contact between agitated reagent and exhaust gas
mins

Fig. 2. Relative speed of oxidation and absorption of carbon monoxide

investigators have shown that these shortcomings of the Orsat procedure can be overcome if, prior to the analysis, the engine exhaust gas is completely oxidized.[4,5,6] This simplification, however, is not altogether convenient if the oxidation of the engine exhaust gas has to be carried out at a high temperature in a furnace fitted with an oxidizing catalyst.

A simplified Orsat technique

In a simplified Orsat technique to be described, the oxidation is confined to carbon monoxide and is carried out within an Orsat apparatus using iodine pentoxide as the reagent. Iodine pentoxide is one of the best known iodine oxides and is available in powder or granulated form. It decomposes easily into oxygen and iodine and thereby is a powerful oxidizing agent. The chemical reaction upon which the conversion of carbon monoxide into carbon dioxide depends, is expressed as follows:—

$$I_2O_5+5CO \rightarrow 5CO_2+I_2$$

With well dehydrated iodine pentoxide this reaction takes place at a temperature 110-130 deg C. Some very precise methods of carbon monoxide determination depend on the liberation of iodine vapour in this process[7,8] but the procedure and the apparatus involved can hardly be detached from an analytical laboratory. This reaction can, however, be utilized for the less specialized analytical routine and can be carried out at a lower temperature if the iodine pentoxide is used in a preparation with fuming sulphuric acid. With a reagent containing approximately 1 part of iodine pentoxide powder in 12 parts of 10 per cent fuming sulphuric acid, the quantitative oxidation of carbon monoxide is effected, as will be seen in Fig. 2, in an appreciably shorter time than that normally needed for its absorption in conventional gas analysers.

This process does not produce any change in the volume of the analysed gas in the apparatus but the content of carbon monoxide prior to its oxidation can easily be assessed by the absorption of the carbon dioxide formed in a 30 per cent potassium hydroxide solution. The liberation of free iodine, while oxidation takes place, which causes the reagent to become tinted, assists in the approximate estimation of carbon monoxide contents below 0·1 per cent[9,10,11] and gives a positive indication when the reaction terminates and all the carbon monoxide has been converted into carbon dioxide. An excess of sulphur trioxide in the reagent, contributes to the instantaneous absorption of the liberated iodine and to the regeneration of the reagent.

With the hydrocarbons of the motor gasoline range, and with the partially oxidized fuel derivatives, iodine pentoxide reagent reacts in a somewhat more complex manner. A little carbon dioxide is produced as the outcome of the reaction, but the predominating oxidation products are of an organic acid nature and are completely absorbed by the reagent. Thus, the reduction of the gas volume caused by the process gives a good approximation of the combustible content other than carbon monoxide, hydrogen and methane. This feature of the iodine pentoxide-fuming sulphuric acid reagent was found very useful in disclosing a misfire within a multi-cylinder engine. At the ambient temperature the reagent does not combine with the free hydrogen and methane.[9,12]

Following the oxidation of CO to CO_2, the total CO and CO_2 in the original sample may be estimated by the reduction in volume after absorption in caustic potash. The air/fuel ratio may then be read directly from the CO_2+CO curve in Fig. 1.

As could be expected from its composition, iodine pentoxide reagent is highly corrosive, and some safety measures against the spillage and accidental contact of the reagent with a water-base confining agent are essential in designing an analyser. Two ways which have proved successful in providing adequate safeguards against this, the only disadvantage of the reagent, are embodied in the apparatus shown in Figs. 3 and 4. The apparatus illustrated in Fig. 3 is a portable type designed for investigations on petrol as well as on diesel engines. For this reason it has an additional pipette for the determination of the free oxygen content of the gas sample. All the main components of this analyser are contained inside a box comprising a metal frame and Perspex screens. These, together with the spillage tray beneath the pipettes, combine in guarding an operator against being splashed by the corrosive reagent should

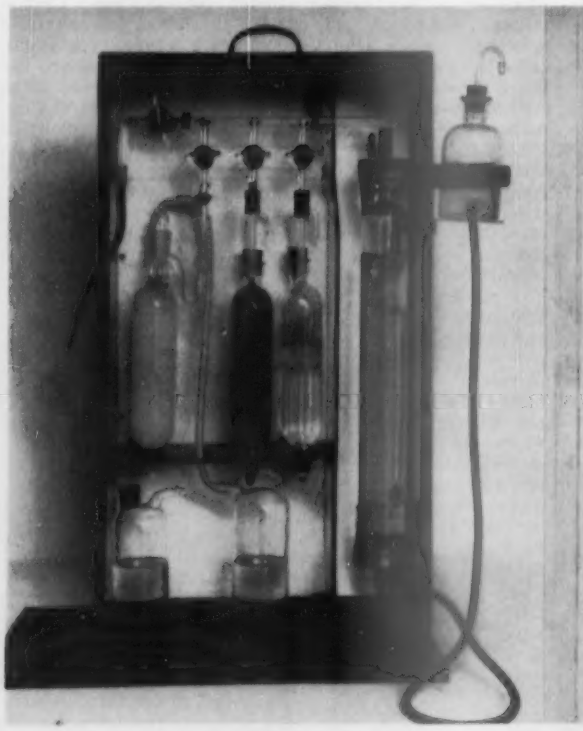


Fig. 3. Portable Orsat apparatus with iodine pentoxide reagent

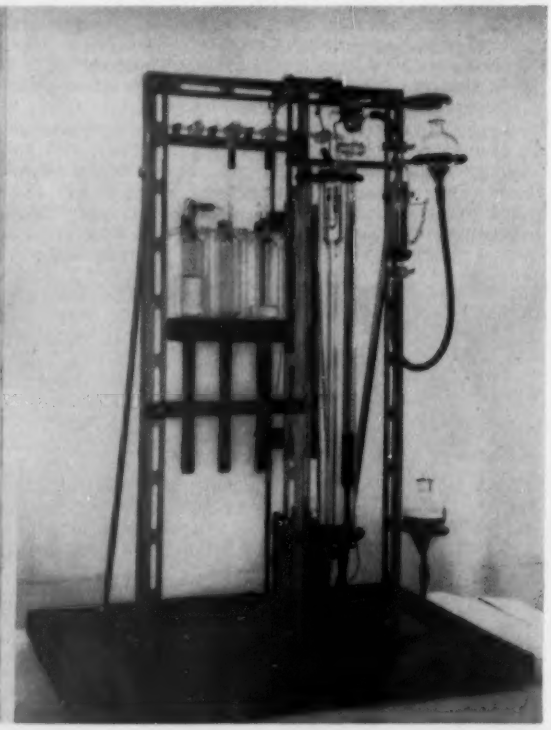


Fig. 4. Laboratory type Orsat analyser with iodine pentoxide reagent

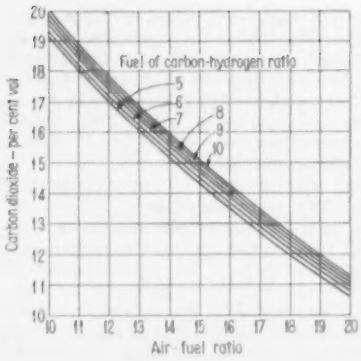


Fig. 5. Calculated relation between percentage carbon dioxide in dry, pentoxide treated exhausted gas and air/fuel ratio

an accidental breakage of a pipette occur. The inlet capillary to the strong Pyrex glass pipette carrying the iodine pentoxide reagent is S-shaped, with its anterior portion expanded into a little sphere. If by some mischance the water-base confining agent is passed beyond the burette towards the pipette, the amount of the reagent retained on the wall of this sphere is adequate to force the confining solution rapidly back as soon as it reaches the sphere, thereby safeguarding the main body of the reagent from the dangerous contact with water. For the same reason it is advisable to use the minimum length of connection between the burette and the levelling bottle, and to keep in it no more water than is absolutely necessary for forcing the gas sample into the pipette.

These latter safeguards are unnecessary in a laboratory type of analyser shown in Fig. 4, in which mercury is used as the confining agent. As will be seen, all pipettes are enclosed here in Perspex ooxes as a safety measure against mechanical damage and spilling of the reagents. The atmospheric limbs of the iodine pentoxide pipettes in both designs are sealed by liquid paraffin to prevent the reagent becoming weakened by the direct loss of sulphur trioxide or by the absorption of water from the atmosphere.

Interpretation of analyses

From the total carbon dioxide content in the oxidized engine exhaust gas, an appropriate air/fuel ratio of the mixture fed to the engine can be assessed using the curves plotted in Fig. 5. The method of compiling each of these curves from two component-curves W and R is shown in Fig. 6. For a fuel of a given carbon/hydrogen ratio, the curve W represents the theoretical relationship between carbon dioxide in dry engine exhaust gas and air/fuel ratio on the assumption that complete combustion has occurred. This assumption is justifiable only under weak mixture conditions. Curve R embodies the same relationship valid for rich mixture running conditions, where it is assumed that no free oxygen is to be found, and that the carbon dioxide present in the iodine pentoxide treated engine exhaust gas, carries all the carbon originally present in the fuel.

Let the symbols CO_2, H_2 and N_2 represent the volume percentage of carbon dioxide, hydrogen and nitrogen respectively in the dry exhaust gases in which all the carbon from the fuel is found in the form of carbon dioxide. Further, let C, H and A represent grams of carbon and hydrogen per gram of fuel and air/fuel ratio by weight respectively.

Under weak mixture conditions, the combustion products for each gram of fuel burned will consist of:—

Moles of carbon dioxide $= \dfrac{C}{12{\cdot}01}$ (ignoring small amount of CO_2 from the air)

„ „ water $= \dfrac{H}{2{\cdot}016}$

„ „ oxygen $= \dfrac{0{\cdot}231A}{32{\cdot}00} - \dfrac{C}{12{\cdot}01} - \dfrac{H}{4{\cdot}032}$

Oxygen supplied from air — Oxygen used in formation of carbon dioxide — Oxygen used in formation of water

„ „ nitrogen $= \dfrac{0{\cdot}768A}{28{\cdot}016}$

The moles of exhaust gas can then be expressed as:—

$$N_2+CO_2+O_2=\frac{0{\cdot}768A}{28{\cdot}016}+\frac{C}{12{\cdot}01}+\frac{0{\cdot}231A}{32{\cdot}00}-\frac{C}{12{\cdot}01}-\frac{H}{4{\cdot}032}$$

$$=A\left(\frac{0{\cdot}768}{28{\cdot}016}+\frac{0{\cdot}231}{32{\cdot}00}\right)-\frac{H}{4{\cdot}032}$$

$$=0{\cdot}0346A-\frac{H}{4{\cdot}032}$$

from which the mole per cent of carbon dioxide in the dry engine exhaust gas will be:—

$$\frac{\dfrac{C}{12{\cdot}01}}{0{\cdot}0346A-\dfrac{H}{4{\cdot}032}}\times 100$$

After simplification, the formula for calculating the mole per cent of carbon dioxide in the dry engine exhaust gas obtained from engine combustion of a mixture weaker than chemically correct will become:—

$$\frac{240{\cdot}6C}{A-7{\cdot}167H}$$

This formula has been used for plotting curve W.

To derive the corresponding formula for rich mixture conditions, a relationship between the hydrogen and carbon dioxide contents in an iodine pentoxide treated exhaust gas is required. After consulting expressions suggested by other investigators[1,2,13] and also the available analyses of petrol engine exhaust gas, including some obtained by the mass spectrometer, this relationship was found to be fairly consistent and its simple linear approximation was established as:—

$$H_2=1{\cdot}065\ CO_2-14{\cdot}8 \text{ per cent by volume.}$$

Retaining the same meaning of symbols the weights of the mixture components required to produce one mole of treated exhaust gas are:—

Weight of carbon $= 12{\cdot}01\ CO_2$

„ „ hydrogen $= 12{\cdot}01\ CO_2 \cdot \dfrac{H}{C}$

„ „ fuel $= 12{\cdot}01\ CO_2\left(1+\dfrac{H}{C}\right)$

„ „ air $= \dfrac{28{\cdot}016}{0{\cdot}768}\cdot N_2$

$\dfrac{H}{C}$ represents here the hydrogen/carbon ration of the fuel used. Retaining the assumption that:—

$$N_2=100-CO_2-H_2$$

and substituting H_2 by the above empirical expression

$$N_2=100-CO_2-(1{\cdot}065\ CO_2-14{\cdot}8)$$

$$\therefore N_2=114{\cdot}8-2{\cdot}065\ CO_2$$

The air/fuel ratio can then be expressed as a function of the CO_2 content.

$$A=\frac{\dfrac{28{\cdot}016}{0{\cdot}768}(114{\cdot}8-2{\cdot}065\ CO_2)}{12{\cdot}01\ CO_2\left(1+\dfrac{H}{C}\right)}$$

$$A=\frac{348{\cdot}7-6{\cdot}30\ CO_2}{CO_2\left(1+\dfrac{H}{C}\right)}$$

from this formula the total CO_2 content can be derived as:—

$$CO_2=\frac{348{\cdot}7}{A\left(1+\dfrac{H}{C}\right)+6{\cdot}30} \text{ mole per cent}$$

This expression was used for plotting the curve R appropriate for rich mixture engine running conditions.

The assumptions made to simplify the construction of the curves W and R become less accurate as the air/fuel ratio approaches its chemically correct value. Hence, the inter-section region of these

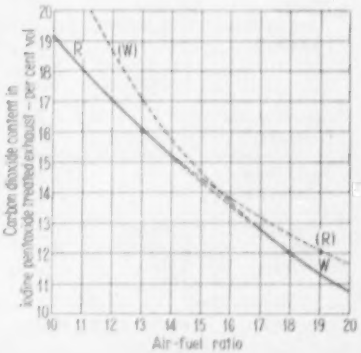


Fig. 6. Carbon dioxide content curve for fuel 5·3:1 carbon/hydrogen ratio

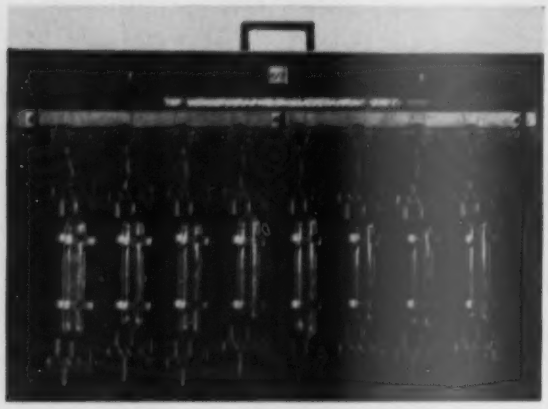


Fig. 7. Engine exhaust sampling panel

two curves should be corrected to conform more closely to the experimental relationship shown in Fig. 1 by the dotted line. This is done by leaving the component curves *R* and *W* unplotted approximately 1½ air/fuel ratios on both sides of the chemically correct mixture; the gap thereby created is interpolated graphically.

Application of the technique

For the assessment of air/fuel ratio by means of either of the analysers described, a sample of engine exhaust gas can be taken directly into the apparatus or, if this is inconvenient, into an evacuated sampling tube. The latter exhaust gas sampling method proved very satisfactory in mixture strength investigations on the road. The eight sampling tubes used for this purpose, conveniently mounted on the panel, are shown in Fig. 7. In this arrangement the tubes can be filled consecutively following the changes in the investigated conditions, and the sample transferred to the apparatus by displacing with mercury. After taking the initial volume reading, when the temperature has stabilized, the gas sample is admitted into contact with the iodine pentoxide reagent, and left for three to four minutes until the reaction is well under way. Subsequently, the gas sample is passed backward and forward to ensure its thorough contact with the reagent and thereby the quantitative oxidation of carbon monoxide.

Experience has shown that where a sample contains not more than 2 per cent of carbon monoxide, two further contacts of at least one minute duration are essential for its complete oxidation. For higher concentrations of carbon monoxide an additional contact is required for every 2½ per cent of carbon monoxide content in excess of the basic level of 2 per cent. That is to say, if the sample contains 12 per cent of carbon monoxide, at least seven contacts, including the longer initial one, are required for its quantitative conversion into carbon dioxide.

As already implied the colouring of the reagent which accompanies the liberation and absorption of iodine can be taken as a guide to the efficiency of the sample oxidation. The disappearance of the greenish tint on the surface of the reagent, is a reliable indication of the termination of the reaction. It is always advisable to recheck the volume of the sample after oxidation, and it is essential to do so when the presence of iodine pentoxide oxidizable constituents other than carbon monoxide are suspected. When the latter is the case, ample indication is given to the experienced operator by the behaviour of the reagent during the oxidation process.

The conventional absorption of carbon dioxide in the 30 per cent potassium hydroxide solution, which follows, is a very efficient process. Normally, four transfers of the sample in the absorbent pipette filled with glass tubes to increase the absorption area are sufficient to complete the reaction. The overall reduction of the sample volume after the absorption of carbon dioxide is concluded, can then be used in conjunction with the curves in Fig. 5 for the determination of the mixture strength.

When dealing with commercial motor spirit the assumption that its carbon/hydrogen ratio is 5·6 : 1 will not lead to any significant error in the assessment of the mixture strength.[4] If, however, the fuel tested departs from the average commercial brand owing to the excess of some components, especially aromatics, its carbon/hydrogen ratio should be determined analytically or, if this is impracticable, by one of the following methods.

When details regarding the predominating fuel components are available the resultant carbon/hydrogen ratio of the fuel can usually be estimated with satisfactory accuracy. From Table I, which is provided to assist in this matter, it will be observed that quite considerable variation in fuel composition will affect only slightly the resultant carbon/hydrogen ratio, provided that these variations do not involve aromatic hydro-carbons which have considerably higher carbon contents than the average motor spirit.

For fuels of higher aromatic content, between 15 and 30 per cent, as normally encountered in catalytically cracked gasoline, a satisfactory approximation of carbon/hydrogen ratio can be made from the formula:—

$$C/H = \frac{74{\cdot}7 + 15{\cdot}6s}{25{\cdot}3 - 15{\cdot}6s}$$

where s represents the specific gravity at 20 deg C of the fuel.

For checking purposes or in cases when very little is known about the origin and composition of the fuel tested, its carbon/hydrogen ratio can be derived with quite adequate accuracy from the two or three simplified analyses of the exhaust gas drawn from the engine when it operates on a very lean mixture. Under these conditions a simplified assumption was previously made that all carbon from the fuel is present in the engine exhaust in the form of carbon dioxide. As before, let CO_2, O_2 represent the volume per cent of carbon dioxide and free oxygen respectively in the engine exhaust gas, then, in its mole volume the weights of all the elements involved will be as follows:—

Carbon from the fuel

$$C = 12{\cdot}01\ CO_2$$

Nitrogen from the air

$$N = 28{\cdot}016\ (100 - CO_2 - O_2)$$

Oxygen from the air

$$O = 8{\cdot}475\ N_2$$

TABLE I. Data on some motor gasoline constituents

Description of Constituent			Boiling Point deg C	Specific Gravity at 60 degF/60 deg F	Theoretical Air/Fuel Ratio	Carbon/Hydrogen Ratio
Type	Name	Formula				
Normal and Iso-paraffins (Alkanes)*	Butane	C_4H_{10}	−0·5	0·584	15·5	4·76
	Isopentane†	C_5H_{12}	27·9	0·624	15·3	5·00
	Isohexane†	C_6H_{14}	49·7	0·654	15·2	5·10
	Iso-octane†	C_8H_{18}	99·2	0·693	15·1	5·30
	Decane	$C_{10}H_{22}$	174·1	0·734	15·1	5·42
Mono-olefins (Alkenes)	—	C_nH_{2n}	—	—	14·8	5·96
Naphthenes (Cycloalkanes)	—	C_nH_{2n}	—	—	14·8	5·96
Aromatics (Alkyl benzenes)	Benzene	C_6H_6	80·1	0·880	13·2	11·92
	Toluene	C_7H_8	110·6	0·872	13·5	10·43
	Xylene	C_8H_{10}	136·2	0·872	13·6	9·53
	Cumene†	C_9H_{12}	152·4	0·866	13·8	8·95
Petroleum	Motor spirit (typical)	—	—	0·72	15·1	5·6

*Names in brackets were adopted by the Geneva Convention (14).

†Hydrocarbons often added to high grade motor gasolines.

Oxygen associated with CO_2 and free oxygen $O' = 32\ (CO_2 + O_2)$

Oxygen associated with combustion water $O'' = O - O'$

Hydrogen from the fuel $H = 2{\cdot}016\ \frac{O''}{16}$ and consequently

Carbon/hydrogen ratio $= \frac{C}{H} = \frac{12{\cdot}01\ CO_2}{2{\cdot}016\ \frac{O''}{16}}$

Summarizing, the technique described offers the following advantages over the alternative methods of air/fuel ratio determination from engine exhaust gas composition:—

1. The apparatus is simple in design and can consist of only two pipettes.
2. Relatively, a very short time is needed for the assessment of the air/fuel ratio under which combustion takes place.
3. With an experienced operator it is possible to repeat results to an accuracy of $\pm 0{\cdot}1$ of a ratio for all mixtures within the range of air/fuel ratio from 11 : 1 to 18 : 1. Outside these limits the accuracy is somewhat lower but the deviations in air/fuel ratio determination greater than $\pm 0{\cdot}2$ of a ratio were very seldom encountered.
4. The disappearance of the greenish colouring which persists on the surface of the reagent during oxidation of carbon monoxide provides a positive indication of the conclusion of the reaction, and so makes the analysis less prone to experimental errors.
5. The carbon monoxide oxidation process takes place without any detectable temperature rise either of the gas sample or of the reagent.
6. Any change of sample volume following contact with the iodine pentoxide reagent indicates the presence of organic compounds. This phenomenon can conveniently be utilized for the detection of engine misfire and also to give an approximate assessment of the combustible content in the sample other than hydrogen and methane.
7. The iodine pentoxide reagent does not deteriorate with time and, provided that it is occasionally agitated to prevent sedimentation and consequent blockage of the narrow passage of the pipette, it can be kept practically indefinitely.

TABLE II. Volumetric Concentration of Iodine vapour in mixed gas after Iodine Pentoxide Oxidation of Carbon Monoxide

Concentration of Carbon Monoxide in Analysed Gas		Approximate Volumetric Concentration of Iodine Vapour in Oxidised Gas	
Parts per Million	Per Cent by Volume	Parts per Million	Per Cent by Volume
1000	0·1	200	0·02
10000	1·0	1996	0·20
100000	10·0	19600	1·96

An iodine vapour method

Another method of air/fuel ratio determination based on the oxidation of carbon monoxide in an exhaust gas by neat iodine pentoxide is embodied in an apparatus shown in Fig. 8. The exhaust gas sampled continuously from the engine passes through a drier and the tube T into two stainless steel reactors R_1 and R_2 in series; both are filled with granulated anhydrous iodine pentoxide. The temperature of this reagent is maintained at approximately 120 deg C by means of an electrically heated ethylene glycol bath, in which the whole body of the apparatus is submerged. At this temperature carbon monoxide reacts spontaneously with iodine pentoxide, forming, as shown earlier, carbon dioxide and free iodine. Hence, the gas leaving the reactor varies in capacity according to the concentration of carbon monoxide now replaced in the gas stream by the iodine vapour. The light absorption property acquired in this way can be assessed quantitatively in the tube V in which the oxidized gas sample is placed between the light source L and the barrier-layer

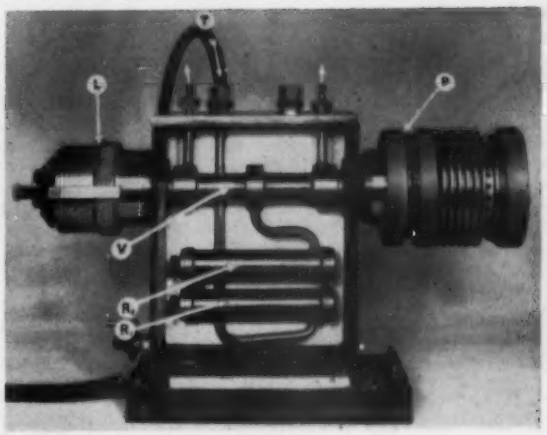


Fig. 8. Continuous co-oxider with viewing tube

type photo-electric cell P. The cell is connected to a micro-ammeter (not shown in Fig. 8) across which a variable shunt resistance is placed to enable adjustment of the meter before the light absorption reading is made. The readings obtained from the meter give numerical values of the percentage reduction S of light caused by the 100 mm long column of iodine pentoxide-treated engine exhaust gas stretched between outlet ports at each end of the viewing tube V, i.e.

$$S \text{ per cent} = \frac{A - E}{A} \times 100$$

where A = Intensity of illumination of the photo-cell when facing the air-filled viewing tube.
E = Intensity of illumination of the photo-cell when facing the iodine pentoxide oxidized exhaust gas column.

If the illumination of the photo-cell is kept within the range of linear response and the corresponding current measured by the meter, I_o and I are proportional to the intensities of illumination, A and E respectively. Then

$$S \text{ per cent} = \frac{I_o - I}{I_o} \times 100$$

A test carried out on a C.F.R. (F4) engine using neat iso-octane as fuel produced the curve shown in Fig. 9, which relates the percentage of light absorption in the 100 mm long sample column with the air/fuel ratio.

Since the percentage of the light absorbed in the viewed gas column depends solely upon the carbon monoxide content of the sampled exhaust gas, the assessment of the mixture air/fuel ratio higher than approximately 16 : 1 in a rather short viewing tube becomes less accurate. This short-coming of the method could probably be overcome by making the viewing tube considerably longer.

As an indication of the quantitative measures involved and as a basis for the assessment of the limitations of the method, the following data may be of some assistance:—

For the oxidation of 1 g CO, 2·38 g of I_2O_5 are required.

For the oxidation of 1 l CO, 2·98 g of I_2O_5 are required.

For every 1 g of oxidized CO, 1·81 g of free iodine will be liberated.

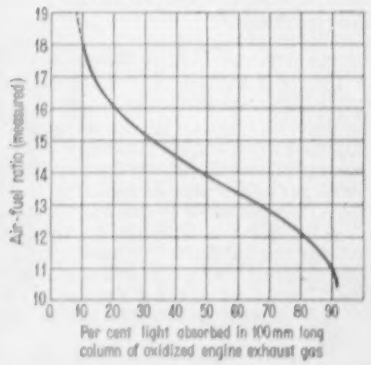


Fig. 9. Air/fuel ratio v. percentage of light absorbed in I_2O_5 oxidized exhaust gas from C.F.R., F4 fuel test engine. Fuel of 15·3:1 carbon-hydrogen ratio

For every 1 *l* of oxidized *CO*, 2·26 g of free iodine will be liberated.

The total reagent capacity of the prototype apparatus (Fig. 8) is approximately 120 grams.

With a flow rate of 5 c.c. of analysed gas per second the oxidizing efficiency of the apparatus begins to deteriorate when the amount of the reagent falls in the bottom tube to about 40 per cent and in the top tube to just over 70 per cent of their original charge. This means that the effective amount of iodine pentoxide in the apparatus is approximately 54 grams, which is sufficient to convert 18 litres of pure carbon monoxide into carbon dioxide with the liberation of 41 grams of free iodine.

With the above rate of flow and an average carbon monoxide content in the analysed gas of 2 per cent, a single charge of the reagent will last for approximately 50 hours of continuous operation of the analyser.

The following may be listed in favour of the method:—

1. The micro-ammeter which records the output from the photo-cell in the viewing tube can be calibrated in percentage of carbon monoxide content or in air/fuel ratios for fuels of an average carbon and hydrogen content.

2. The apparatus can operate in conjunction with a recorder.

3. The reagent employed is safe and durable.

4. By collecting the iodine carried away by the oxidized exhaust gas the reagent can easily be reconstituted. It can also be utilized in a pure state or in the form of tinctura iodi.

5. The apparatus can be made compact and portable and, as such, used in vehicles on the road, in mines etc.

6. The method offers wide scope for further refinement and applicability. With the photo-electric detection technique, smaller concentrations of carbon monoxide can be measured in a longer viewing tube. Still further increase in sensitivity of the method could probably be achieved by using iodine pentoxide prepared from iodine 131 and by applying the scintillation counting technique for the radioactive assay of the oxidized gas sample.

The apparatus in its prototype form is not, however, completely devoid of faults and shortcomings. Some of them, such as not entirely satisfactory distribution or heating of the reagent, are inherent in the design of the instrument but may be alleviated in its further development. The others, which are caused by the adverse effect of the moisture and higher hydrocarbons on the behaviour of the reagent, can be overcome by providing an effective drying stage in the gas sample line and by preventing the fuel contaminated exhaust gas from entering the apparatus. Should frequent misfiring of a test engine be unavoidable, some effective measure could be incorporated for extracting the unburned fuel from the gas sample. Activated charcoal may be useful in this respect.

When aiming for high accuracy there is also insufficient evidence to show that the carbon monoxide content in the exhaust gas from an engine depends on the mixture strength only, and that no other factors such as rate of turbulence, ignition timing, pre-ignition or detonation interfere with this relationship.

Résumé

In conclusion, it has been demonstrated that iodine pentoxide offers evident advantages when used in instruments devised for measuring the air/fuel ratio of gas mixtures supplied to an engine. Both the methods described provide adequate accuracy in the determination of air/fuel ratio for most practical purposes and, if necessary, the accuracy can be further increased by suitable refinements in the techniques. The first method, featuring the use of iodine pentoxide with fuming sulphuric acid in a modified Orsat apparatus, is simple and accurate. Although it can be adapted for use in moving vehicles it is more suited for use in a test laboratory, where engine exhaust gas samples are supplied in a conventional manner.

The second method, in which dry iodine pentoxide is used as a reagent, is applicable for continuous indication or recording of the air/fuel ratios both for engines on the test bed or on the road.

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GAS CARBURIZING AND CARBONITRIDING

Modern American Practice and Equipment

N. K. Koebel*

IN comparison with the older method of pack carburizing, gas carburizing has the following advantages:—

(a) Lower cost.
(b) Control of carbon in the case.
(c) Automation of equipment.

Lower carburizing costs are made possible because less time is required to heat the work alone than is required for heating the work plus the container and carburizing compound. Furthermore, the carburizing compound acts as a shield or insulator that prevents the work from absorbing heat quickly. From a cost point of view, carburizing gas per pound of work treated is much cheaper than carburizing compound. Perhaps the greatest saving results from reducing the amount of labour required for handling the carburizing compound and work in to and out of the containers. This is particularly so in America where labour costs are high.

Metallurgically, gas carburizing makes it possible to control the carbon content of the case. This is not possible with pack carburizing, since pack carburizing produces saturated austenite at the temperature of carburizing; for example, at 1700 deg F (925 deg C) the percentage of carbon at the surface of the case would be approximately 1·25. In America the trend is now to carburize to controlled carbon contents between 0·75 and 0·90 per cent. The reason for this was to eliminate the tendency to have retained austenite, especially in alloy steels. Another reason is to eliminate a steep carbon gradient that may cause spalling. Yet another reason is to reduce distortion. Generally speaking, controlling the carbon in the case between 0·75 and 0·90 per cent has reduced rejects and failure of parts in service.

The fact that gas carburizing lends itself to the design of automatic furnaces is another important reason for its use. The automation of equipment reduces labour which, as pointed out above, is a big factor in costs in America. Furthermore, the automation of equipment creates better working conditions to satisfy labour. In America it is becoming exceedingly difficult to obtain labour for dirty, back-breaking jobs such as handling pack carburizing. Furthermore, the automation of equipment reduces the human error and permits better quality control.

Early gas carburizing practice

The first gas carburizing furnaces were vertical, retort batch furnaces using a hydrocarbon fluid to generate the gas in the furnace. The hydrocarbon fluid was drip-fed into the furnace on to a hot alloy baffle which caused the fluid to volatilize and react with the air in the furnace to produce a gas of hydrogen, carbon monoxide, methane and nitrogen. With a tightly sealed retort it was possible to control the amount of fluid to generate a carburizing gas. Later, such gases as natural gas or propane were also used in place of the fluid.

This early method of gas carburizing by fluid or straight natural or propane gases had several disadvantages. Controlling the amount of fluid to eliminate sooting was not always easy. Soot interferes with carburizing by tending to prevent the nascent carbon from reacting with the steel surface. Nascent, atomic carbon, not molecular carbon, such as soot or coke, is required for gas carburizing. Sooting or coking slows down the carburizing process. Furthermore, soot increases the cleaning costs of the parts and excessive soot in the furnace increases the maintenance cost. With the drip-feed hydrocarbon oil or straight natural gas process, it is difficult to control the content of the carbon in the case by the diffusion process. Another reason why the drip-feed hydrocarbon oil or straight natural or propane gas processes have become out-of-date in America is that they can be used only on tightly sealed retort, batch type furnaces. On continuous furnaces which require a large volume of gas for purging to counteract the effect of opening the doors during the carburizing cycle, excessive soot would be formed if straight hydrocarbon oils or gases were used.

Modern gas carburizing practice

Modern gas carburizing practice is to use a separate and controllable carrier gas enriched with a hydrocarbon gas to obtain fast carburizing during the initial stage of carburizing. A carrier gas is a completely reacted hydrocarbon gas with air consisting of hydrogen, carbon monoxide, nitrogen, a small but controllable water vapour content, and with the hydrocarbon content under one per cent. The fact that the hydrocarbon content is under one per cent makes it a completely reacted gas. With such a gas the water vapour content can be adjusted to make the gas in equilibrium with any carbon content steel.

To get fast carburizing, however, it is desirable to have as high a carbon potential as possible with a certain amount of a hydrocarbon gas such as methane to crack on the work to produce nascent or atomic carbon. To obtain a gas that will produce a saturated austenite on the surface so as to provide a high carbon gradient for rapid diffusion and carburizing, a small amount of hydrocarbon gas, such as natural gas, propane or butane, is added to the

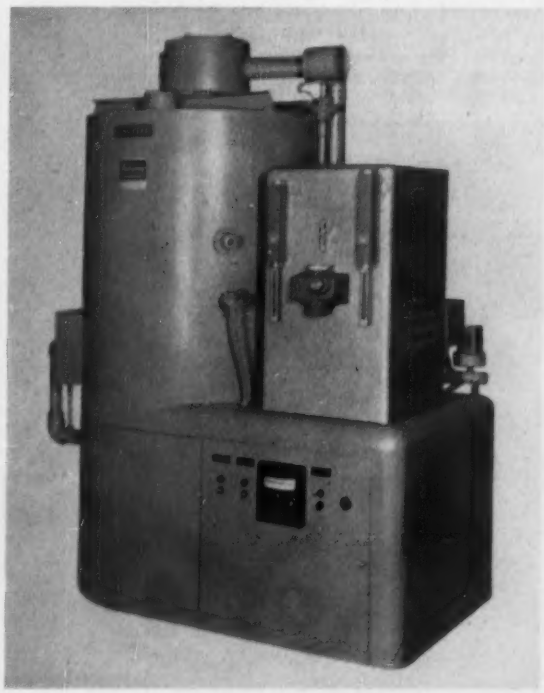

Fig. 1. Lindberg endothermic generator as used in America

*Associated with Electric Resistance Furnace Co. Ltd., Weybridge, Surrey.

carrier gas. The amount added depends on the total surface area of the work carburized and not the weight of the charge, since the surface area creates the demand for the carbon and thus the amount of hydrocarbon gas. The amount of hydrocarbon gas must be controlled to prevent sooting from taking place on the work. This is done by trial and error or by instrumentation. During the last stages of the decarburizing cycle, the hydrocarbon gas is shut off and the carbon in the case is allowed to diffuse inward and outward to the atmosphere of the carrier gas, which is adjusted for the carbon content desired. By this method a controlled carbon in the case can be produced and work free from soot, in fact bright, can be obtained. In the case of continuous furnaces, carrier gas only is used in the diffusion zone to control the per cent of carbon in the case.

Principle of the endothermic generator to produce the carrier gas

The endothermic (heat absorbing) type of atmosphere has been accepted by American industry as the most convenient and practical for preparing furnace atmospheres for carrier gas for carburizing, carbonitriding and for the neutral hardening of medium, high-carbon and tool steels. In fact, the endothermic generator is fundamental to all controlled atmosphere heat treating and, therefore, a knowledge of this process is necessary if modern gas carburizing and carbonitriding and the related processes of neutral hardening are to be understood. The primary reason for the use of the endothermic generator throughout industry in America is that natural gas (90 to 95 per cent methane), now available at a low cost throughout America, can easily be cracked to produce a consistent atmosphere to meet the requirements of neutral hardening, carbon correction, gas carburizing, carbonitriding, and homogeneous carburizing without elaborate gas generating equipment requiring chemical purification and drying towers. The endothermic generator can be operated by any shop man, and the only instrument required to adjust the generator to ensure that it is in equilibrium with a steel of any carbon content is a simple dew-point meter, or an instrument for measuring moisture in the gas it produces. This statement is made with confidence, since the research laboratory of the Lindberg Engineering Company has completed a five-year study of equilibrium relationships between the dew-point of endothermic furnace atmosphere and straight carbon steels, low-alloy production steels, and tool steels.

Although it has been mentioned that natural gas is used in America, the endothermic generator will work equally well cracking propane, butane or any other hydrocarbon gas. Manufactured gas is also suitable, but is not as desirable as propane or butane, because it may vary in chemical analysis and this creates a more difficult control problem of producing a furnace atmosphere to a definite carbon potential by the dew-point method.

In Great Britain, manufactured or town's gas is used for cracking in the endothermic generator almost exclusively, without any great difficulty. If propane or butane is used the raw gas must not have over 5 per cent unsaturated hydrocarbon gases such as propylene or butylene. Unsaturated hydrocarbon gases will not crack properly and will soot the catalyst. If the above specifications are met, the endothermic generator will work as well in Europe as in America. In fact, some localities in America operate on propane or butane and some operate on manufactured gas. Thus the statement which is often heard in Europe, that gas carburizing is successful in America because of natural gas, is not correct. America uses natural gas where available because of its low cost. Where it is not available, it is still possible to make use of the advantages of gas carburizing and heat treating by modern controlled atmospheres.

In the endothermic process, hydrocarbon gas and air are metered in such a proportion that there is just sufficient oxygen to form carbon monoxide and hydrogen without any excess for carbon dioxide or water vapour. After the air-gas mixture is compressed to about 1 or 2 lb gauge, the mixture is passed through a fire check and then to the heated catalyst in a pressure-tight retort heated externally (usually by gas firing). The temperature of the catalyst is extremely important to obtain a gas completely reacted and of consistent analysis. A temperature from 2,000 to 2,200 deg F in the heating chamber outside the retort results in a completely reacted and stable gas mixture.

After the gas passes over the catalyst, the reaction is "frozen" by chilling the gases to 600 deg F (315 deg C) in a water jacket surrounding the top of the retort, thus preventing the reaction from reversing and forming carbon and carbon dioxide from carbon monoxide. (The reaction in that direction occurs in a temperature range from 1,300 deg F (705 deg C) downward to 900 deg F (485 deg C).) The soot-free reacted gas can be further cooled in the gas cooler for metering and distribution purposes if desired.

Considering natural gas to be composed chiefly of methane (CH_4), the over-all chemical reaction taking place in the endothermic generator may be written:—

$$2CH_4 + O_2 + 3{\cdot}8N_2 + 2CO + 4H_2 + 3{\cdot}8N_2$$

This overall reaction is not endothermic as the generator's name implies, but actually exothermic. However, reaction takes place in two stages. In the first stage, some of the methane burns with the air and, of course, generates heat. In the second stage, the surplus methane reacts with the carbon dioxide and water vapour produced in the first stage, and this second reaction is definitely endothermic. Therefore, a high temperature and sufficient catalyst bed are required to obtain complete reaction so there is no carbon dioxide, excess methane or excess water vapour in the final atmosphere. A reversible reaction is then prevented by "freezing" the reaction, as explained above.

The air-gas ratio can be altered slightly to vary the dew-point (moisture content) of the gas without appreciably affecting the carbon dioxide or residual methane. From a

Fig. 2. Efco-Lindberg generator, carbotrol unit and carbonitriding furnace

35 deg F dew-point down to 0 deg F dew-point, there is no carbon dioxide in the atmosphere. The residual methane ranges from zero to approximately 1·5 per cent if the generator is operating efficiently. If the dew-point is above 35 deg F, no methane will be present but the carbon dioxide will steadily increase as more air is used in the air-gas ratio until at a 70 deg F dew-point this will be about one per cent CO_2. Experience has proved that dew-points from 70 deg to 10 deg F will be in equilibrium with steels containing from 0·20 to 2·0 per cent carbon content. Fig. 1 shows a Lindberg endothermic generator as used in America to-day.

In order to obtain precise data for controlling the carbon potential of furnace atmosphere for carburizing, carbonitriding, carbon correction, neutral hardening and furnace brazing at high temperatures, the Lindberg Engineering Company developed a set of equilibrium curves by a laborious method of exposing hundreds of samples of steel to a range of dew-points from 0 deg F to 70 deg F at heat treating temperatures of 1400 deg F (760 deg C) to 2100 deg F (1150 deg C). This empirical development of curves was found necessary because the theoretically calculated curves did not agree with the results found in practice.

The application of the equilibrium curves to gas carburizing is to adjust the dew-point of the endothermic generator gas to that shown on the curve for the carbon content desired at the carburizing and diffusion cycle.

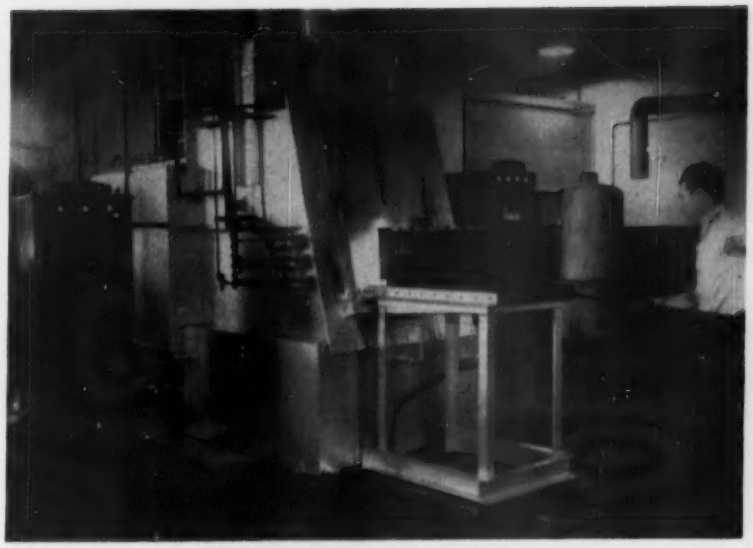

Fig. 3. An Efco-Lindberg carbonitriding furnace

At the beginning of the carburizing cycle, add 8 to 10 per cent natural gas or 3 to 5 per cent propane or 1 to 3 per cent butane, depending on the surface area of the work to be treated. At the end of the cycle, shut off the hydrocarbon enrichment and allow the carbon in the case to diffuse inward and outward to obtain the carbon content as shown on the equilibrium chart.

Equilibrium curves are also very useful for "homogeneous carburizing," which may be defined as carburizing a low-carbon steel throughout to a uniformly higher carbon. This process is used to advantage to carburize low-carbon steel stampings (up to $\frac{1}{8}$ in thick) in preference to working a 0·70 per cent carbon annealed sheet. More complicated stampings with sharp bends can be formed without cracking, and, furthermore, the low-carbon steel is considerably cheaper. The heat treatment cycle is longer on these stampings, but the process is still more economical than using the higher carbon steel. There is considerable saving in tool life by blanking and forming the low-carbon steel instead of the high-carbon steel.

Fig. 4. Efco vertical batch type furnace for motor gears and similar components

The endothermic atmosphere equilibrium curves are particularly useful in the carbon correction of steel. Aircraft specifications in America for such things as bolts require that any "mill bark" on the surface can be recarburized to the content of the core. Bolts with rolled threads are one example where decarburization is not removed in manufacture, and inasmuch as low carbon on the surface of the thread lowers its fatigue properties, specifications for highly stressed bolts now call for carbon correction. To this end, all that is required is to allow the bolts to soak long enough at the hardening temperature with the dew-point adjusted in the furnace as shown on the equilibrium curve for the steel being treated.

For example, if an S.A.E. 4140 steel were being heat treated and simultaneously carbon corrected, a hardening temperature of 1600 deg F (870 deg C) would be used, and the equilibrium shows that a furnace dew-point of 52 deg F would be in equilibrium with this steel. If the bolts were soaked long enough at 1600 deg F, the carbon would be restored to 0·40 per cent and there would be no danger of exceeding this amount regardless of time and temperature. (Usually a soak about twice that required for normal hardening is required.)

The application of the equilibrium curves for endothermic furnace atmosphere for neutral hardening is quite obvious. All that is required is to adjust the endothermic generator and flow of atmosphere through the furnace so that the indicated dew-point temperature is maintained in the furnace chamber at the hardening temperature for the steel being treated. Lindberg Engineering Company has also developed a set of curves for the high alloy tool steels.

At the present time in America, the majority of installations are controlled

Fig. 5. An Efco continuous pusher, three-track gas carburizing furnace for transmission components

manually by the use of an Alnor indicating dew-point meter. This make of meter is very reliable for both low and high dew-points. The instrument is easy and fool-proof to operate and the results are reproducible by any shop man. Lindberg Engineering Company have just recently developed an automatic, controlling, recording dew-point device known as the Carbotrol. With this instrument the operator can set the dew-point desired in the furnace and the instrument will automatically control the furnace to that dew-point and thus to a definite carbon potential. This instrument, together with the Lindberg endothermic generator and a Lindberg automatic batch type carburizing and carbonitriding furnace, is shown in Fig. 2. Automatic control of carbon potential is being given a great deal of study and development in America, and within the next few years great advances should be made in this important field.

In applying the equilibrium curves by either an indicating manually operated dew-pointer or by an automatic recording controller type such as the Lindberg Carbotrol, it is of utmost importance that the dew-point be taken from the furnace chamber and not the generator. The sampling tube must be a high alloy pipe or tube, preferably Inconel. Ordinary steel or low alloy will oxidize and cause erroneous readings. If the sampling tube is to be a permanent one, the tube should extend well through the refractory wall. The end must be kept as close as possible to the work, and the furnace door must not be left open while dew-points are taken. It is necessary to ensure that abnormally high dew-points which occur on starting up the equipment do not form condensate in the sampling tube.

The modern gas carbonitriding process

The carbonitriding process is a gaseous method of applying a carbon and nitrogen case. This process was developed to replace the liquid cyanide method of case hardening. The same endothermic gas generator as described for gas carburizing is used for the carrier gas in the carbonitriding process. There is one difference between the gas carburizing process and the carbonitriding process in that a third gas, anhydrous ammonia, is added to supply nascent nitrogen. The temperatures of carbonitriding are generally carried out between 1500 deg F (815 deg C) and 1600 deg F (870 deg C) whereas the deeper case carburizing is carried out between 1600 deg F (870 deg C) and 1750 deg F (955 deg C) to obtain faster diffusion. Carbonitriding is normally used for light and medium cases from 0·003 in to 0·020 in.

A typical atmosphere to produce a carbonitrided case is one composed of an endothermic atmosphere containing 2-4 per cent propane and 5-15 per cent anhydrous ammonia. The percentages are based on the amount of endothermic carrier gas used in the furnace. For the best results, the dew-point of the gas in the furnace should be adjusted between 30 and 40 deg F. The exact percentages of enriching gas and ammonia vary with the temperature used and the desired case characteristics. The character of the case can also be controlled by the temperature. The lower the carbonitriding temperature, the greater will be the nitrogen in the case and thus the greater will be the hardenability of the steel treated, while the higher the temperature the greater will be the carbon in the case. This will hold true without changing the gas composition. As stated above, the degree of nitrogen and carbon can also be varied by changing the composition of the gas by varying the hydrocarbon enriching gas, the ammonia and the dew-point of the endothermic carrier gas. Thus the process gives a great deal of flexibility.

There are so many advantages of the carbonitriding process over liquid cyaniding that the latter has become obsolete in America to-day. No one would think of installing or replacing salt bath equipment.

The chief advantages may be listed as follows:—

A. Lower cost of operation.
B. Elimination of dangerous cyanide furnaces.

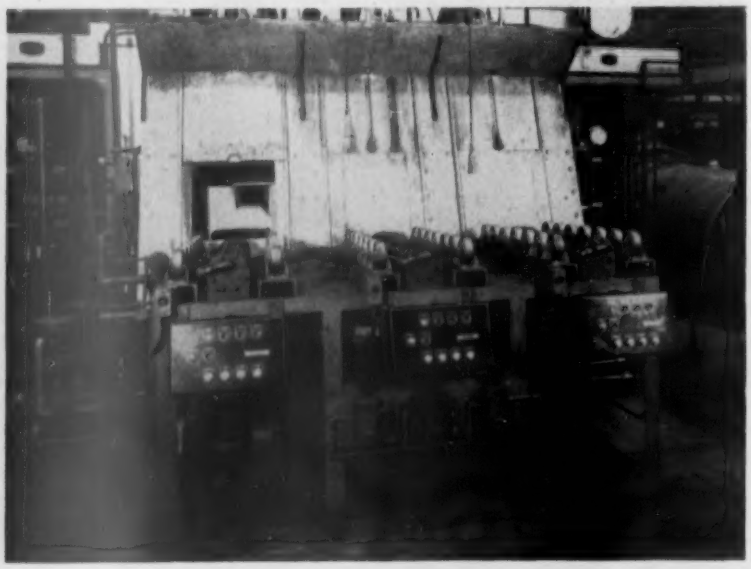

Fig. 6. The charging end of the furnace shown in Fig. 5

C. Elimination of cyanide disposal problems.
D. Elimination of washing cyanide from work.
E. Creation of healthier and better working conditions.
F. Lower labour cost for operation.
G. Control of type of case.
H. Easier automation of equipment.
J. Use of cheap free machining steels in place of the more expensive alloy carburizing steels.

Cost of operation with the carbonitriding process is lower than with salt cyanide because the average cost for the drag out of cyanide per pound of work treated is five cents, whereas the cost of atmosphere for carbonitriding is a fraction of a cent. Furthermore, salt baths have a high radiation loss whereas the carbonitriding furnaces are well insulated and most of the heat energy goes into the work being treated. Salt baths also have higher maintenance costs than furnaces. Considerably more labour must be used to operate cyanide baths because of handling the work in and out of the salt, stringing the work for heating and quenching. In the carbonitriding method the work can be random loaded into baskets up to 300 to 400 lb and batch quenched without coming into contact with the air. The furnace is mechanized in that the operator does not have to handle the work during quench. Furthermore, the work comes from a carbonitriding furnace bright and free from salt, thus eliminating a washing problem which can become troublesome if parts have blind holes. If the carbonitrided work is not to be plated, the oil film can be left on for corrosion protection and the parts can go directly into production. If the parts are to be plated, the oil film can be easily washed off and the parts can go directly into the plating baths. There, again, money is saved in handling and also in extra cleaning operations.

Fig. 7. Efco-Lindberg vertical gas-fired radiant tube batch type gas carburizing furnace with atmosphere circulating fan in the lid

Another great saving and the elimination of a very difficult and troublesome problem is that of cyanide disposal. All localities in America prohibit the dumping of cyanide salts or wash water from cyanide into sewers and streams. This means that either a costly method of neutralizing the cyanide waste by a chemical means is employed or the cyanide is disposed of by an equally costly method of burying it in a deep hole. Perhaps the greatest saving of all is the elimination of the cyanide disposal problem.

Along with the cyanide disposal problem every manufacturer wishes to do away with the poisonous cyanide and the unhealthy working conditions around a cyanide salt bath. There is no worse job in a heat treating room than to work on a cyanide bath and breathe the irritating fumes of sodium carbonate and to be splashed with cyanide from the quench tank. Labour is becoming more difficult to obtain and please, and if something were not done about cyanide salt baths there would be few operators left in America to man them. In conjunction with the demand, the carbonitriding furnace is easy to make automatic in operation.

Aside from all the above savings and advantages, the carbonitriding furnace lends itself to better metallurgical control. The character of the case can be varied to suit the application as described above. Cyanide produces a steep gradient, and where a grinding operation is to be performed the high hardness and wear resistance is lost if only a few thousandths of an inch are removed from the surface. The carbonitriding process produces a gradual gradient, with high hardness well below the surface, so that a grinding operation does not remove the hardness or wear resistance. Furthermore, the elimination of the salt film, which acts as an insulation, permits carbonitrided work to be oil quenched and eliminates the necessity for the more severe water quenching. This eliminates warping and gives much better control over distortion and change in dimensions. The elimination of the salt also permits batch quenching, which has already been described in savings on labour for handling work. Furthermore, the high hardenability produced by adding nitrogen to the steel permits the use of a cheap free-machining steel instead of a more costly alloy steel that is also more costly to machine.

Modern batch type carbonitriding furnaces made by Lindberg and E.F.C.O. can be made completely automatic. All that the operator has to do is to place a charge into the purging vestibule, which is also the quench chamber of the furnace. When the door closes, a timer will allow the load to be purged free of air in the protective atmosphere. The load will then be automatically charged into the furnace. At the end of the proper cycle set by a timer, the load will be automatically pushed from the furnace chamber on to the elevator for quenching. The load quenches automatically and at the end of the quench cycle a signal is flashed as an indication to the operator to remove the load and charge a new one. In this type of furnace there is an upper atmosphere quench chamber for use in annealing or slow cooling the charge when desired. Thus, the furnace can be used for carbonitriding, carburizing, annealing or neutral hardening by merely adjusting the furnace atmosphere for the process desired. The quench system has its own automatic cooler and a powerful oil agitator for

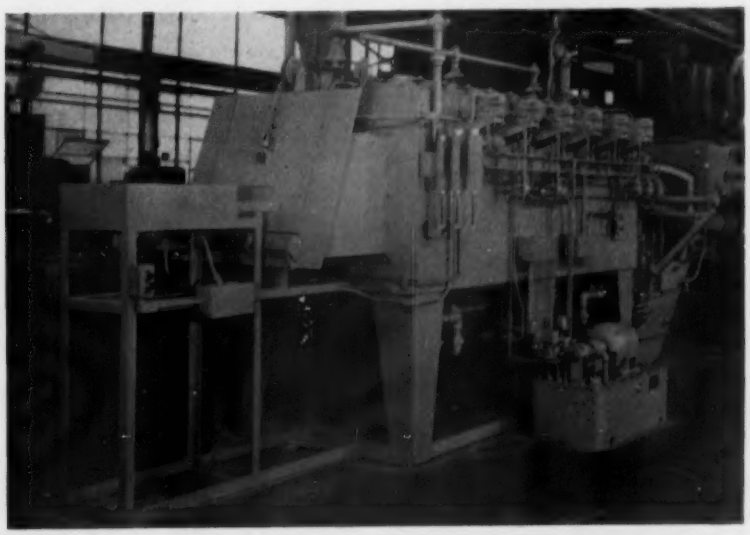

Fig. 8. Single track, pusher type furnace for gas carburizing and carbonitriding

batch quenching. Heaters can also be placed in the oil quench for martempering between 350 deg F (175 deg C) and 450 deg F (230 deg C) to reduce distortion. This method is being used to great advantage in America. A special high temperature marquench oil is used for the process. Fig. 3 shows an Efco-Lindberg carbonitriding furnace now being very successfully used in America and England.

Design of modern gas carburizing and carbonitriding furnaces

Practically all the latest gas carburizing and carbonitriding furnaces in America are designed for radiant tube gas firing. There are several reasons why gas is preferred to electricity. In the first place, gas is cheaper and is available almost everywhere in America. Natural gas pipe lines now extend to almost every corner in the United States and are being installed throughout Canada. The use of a gas fired radiant tube promotes better efficiency than muffle furnaces of either the gas or electric type. Large muffles are costly and the maintenance is greater than that of radiant tubes. To date, electric radiant tubes have not been too successful, the reason being that it is difficult to release the electric energy through an alloy surrounding tube without burning out the electric resistor due to overheating. If the watts density is kept very low to overcome this problem, the radiant tube becomes very large for a small amount of input. Therefore, the furnace chamber must be made larger and the initial cost greatly exceeds that of the gas radiant tube. However, Lindberg Engineering Company is now doing a great deal of research and development work on an economical electric radiant tube for localities in Europe which do not have gas.

The latest development in gas radiant tubes is the Lindberg vertical radiant tube. This tube is a seamless wrought Inconel tube with special "dimples" placed in the tubes to cause turbulence to obtain mixing of the gases and a wiping action on the walls of the tube for efficiency. Since the tube is made of the best heat resisting alloy, long life can be obtained at high temperatures of 1750 deg F (955 deg C) for carburizing, and the tube can be operated intermittently at 1850 deg F (1010 deg C) for stainless steels and high carbon-high chromium tool steels. One of the big problems with gas fired radiant tubes of the "U" bend or hairpin horizontal type was that the tubes usually burnt out at the bend. Another fault was that the bends were welded in and the carburizing gases attacked the welds and caused leaks. Still another disadvantage of the hairpin horizontal type was that the tubes and bends were of a lower alloy cast material. Most castings are porous and thus the carburizing gases would deposit carbon in the pores and cause failure of the tube. Still another problem with the horizontal radiant tubes was that carbon or soot would deposit on top of the tubes and cause hot spots which caused excessive heating and failure. Another problem was that the horizontal tubes were bulky and difficult to install, requiring the furnace to be shut down and cooled. The Lindberg vertical radiant tube only weighs 28 lb and can be installed very easily while the furnace is hot by slipping the tube out of a packing gland at the bottom of the furnace and out of a sand seal on top of the furnace.

Experience in America has proved the life of the older designed horizontal hairpin type of tube to be approximately 8 months at a carburizing temperature of 1700 deg F (925 deg C). To date, after three years of operating the new Lindberg vertical radiant tube, reports show that the average life has been increased to 16-20 months at the same operating temperature. Some furnaces are operating with the original tubes, now over three years old. The Lindberg vertical radiant tube is perhaps the greatest single furnace development for economy in furnace history. Of course, along with the tube, the proper burners and combustion equipment were developed to obtain combustion efficiency in relatively short tube. Furnaces operating in England built by Electric Resistance Furnace Company work as efficiently on manufactured gas as do Lindberg furnaces operating on natural gas in America.

Various types of modern gas carburizing and carbonitriding furnaces that employ the Lindberg vertical radiant tube are shown in Figs. 4, 5, 6, 7 and 8. An Efco vertical batch type, gas-fired, radiant tube gas carburizing furnace is illustrated in Fig. 4. Its working dimensions are 2 ft 6 in diameter × 3 ft 6 in deep, and it is used for motor car gears and similar parts to produce case depths from 0·065 to 0·085 in.

An Efco continuous pusher, three track type gas carburizing furnace for motor car transmission components is shown in Figs. 5 and 6. This furnace is fired by 100 Efco-Lindberg vertical radiant tubes. The output is 530 lb per hour with a case depth of 0·030—0·040 in. Fig. 7 shows a vertical batch type gas carburizing furnace with an atmosphere circulating fan in the lid.

A single track, pusher-type furnace for gas carburizing and carbonitriding is shown in Fig. 8. The work is carried through the furnace on a tray and is quenched direct from the tray. For neutral hardening this furnace can have a throughput of 550 lb per hour, and for flash case carbonitriding (0·003—0·005 in), one of 475 lb per hour. For medium case carburizing (0·030—0·040 in) output can be in the order of 240 lb per hour, and for heavy case carburizing (0·050-0·060 in) in the order of 130 lb per hour.

AMERICAN POWER UNITS

THE 1955 American overhead valve V-8 engines for passenger cars have compression ratios ranging from 7·5:1 to 9:1. Improved breathing is sought through the use of larger valves and increased valve lift. Chrysler uses a single rocker shaft per cylinder head in the smaller displacement engines. Chevrolet and Pontiac have replaced rocker shafts by a pressed steel rocker arm pivoted on a spherical bearing.

Combustion chambers are either as-cast or completely machined. Piston dome height has been increased in the 1955 Buick combustion chamber to give a compression ratio of 9:1. Compared with the 1953 version, the chamber is more compact. A compression ratio of 9:1 is also employed on the Cadillac. The combustion chamber is completely machined, and is a wedge-shaped highly turbulent type that is finding wide favour.

On the Chevrolet, the compression ratio is 8:1. The as-cast, wedge-shaped combustion chamber is designed for combustion control and smooth running. A flat top piston is employed.

In the 1955 Ford, the so-called kidney section has been eliminated from the combustion chamber. The resultant wedge-type chamber gives improved exhaust valve cooling and reduced sensitivity to fuel octane rating. These compact, as-cast chambers have large valves placed side-by-side and large squish area with a consequent improvement in combustion.

Oldsmobile as-cast combustion chambers give an increased compression ratio of 8·5:1. They are compact and are designed for the optimum utilization of current fuels. The Pontiac combustion chamber is wedge-shaped. It includes a thin quench area 0·055 in deep, covering 35 per cent of the piston head. This arrangement promotes turbulence and shortens effective flame travel. The chamber shape lends itself to complete machining. Two basic types of combustion chamber are employed on Packard engines; as-cast for the smaller and fully-machined for the larger displacement engines. Both are of compact wedge form.

Both the twin rocker shaft and the single rocker shaft design produced by Chrysler aim at conservative compression ratios to permit knock-free performance with regular service-station fuels. The separate rocker shafts for intake and exhaust allow the valves to be laterally disposed. *M.I.R.A. Abstract* 55/4/13.

ENGINE CLEANLINESS

*The Action and Effect of Detergent Motor Oils**

DETERGENCY may be defined as that property of oils which tends to minimize deposits and thereby helps keep engines clean. Oils possessing this property are known commonly as "heavy-duty" oils, a term which is unsatisfactory in many ways because of the fact that variations in detergent effectiveness can be, and are, appreciable in practice. There are a number of different detergents actually being used in crankcase oils, and many more are theoretically possible. These materials are not all equally effective when used in the same proportions with similar base oils, and the results obtained in a given instance depend upon the selected base oil, type and concentration of detergent used, and the type of equipment and service in which the finished oil is employed.

Detergent oils are invaluable in promoting useful cleanliness in the vast majority of piston engines. The operation of an internal-combustion engine is inherently one that produces heat, large quantities of waste gases and solid debris, directly from the combustion process itself and indirectly from extraneous contamination: unless their tendency to promote deposits or collect inside the engine as deposits can be controlled effectively, the unit suffers a progressive decline in operating performance and efficiency.

In recent years, as the use of detergent oils in automotive diesel and petrol engines has become more widespread, there has been an increasing interest in how they function and what they may be expected to do. During the past fifteen years Vacuum Oil Company, Ltd. have released information dealing with the outstanding benefits to be derived from detergent oils, especially when used in new or reconditioned engines, each memorandum reflecting the knowledge available at the time of its release. The publications urged caution in regard to indiscriminate changeover from non-detergent to detergent oils. They pointed out the advisability of cleaning oil sumps and other engine covers, when they were known to be exceptionally dirty, before introducing the new type of oil, in order to assure maximum benefit from its use. Long experience with detergent oils now teaches that the improvement in automotive engine cleanliness is gradual rather than rapid and can be attributed to slow attrition rather than quick scouring. Enquiries are received from time to time as to the mechanism of detergency and, in particular, what results may be expected in the way of cleaning up dirty engines. This memorandum is an attempt to answer such questions. It also includes an explanation of how detergent oils assist in keeping engines clean.

* *A communication, engineering memorandum 1026, from the Automotive Engineering Department, Vacuum Oil Company Ltd.*

Deposit sources

Engine deposits have numerous sources. Briefly, they are as follows:—

(1) Atmospheric dust and road dirt—carried into an engine with the combustion and crankcase ventilation air, to a varying degree depending on air-cleaner and breather-pipe filter efficiencies and tightness of the air passages against inward leakage of air.

(2) Casting sand and mill scale, left through incomplete cleaning of parts during engine manufacture.

(3) Metallic "fines" — from engine break-in and subsequent wear, either normal or accelerated.

(4) Lubricating oil deterioration products—from oxidation of an unstable oil or of a high-quality oil left in service too long; or from high-temperature "coking," a thermal-decomposition process which does not require the presence of oxygen.

(5) Fuel combustion by-products—soot, unburned and partially burned fuel, complex organic acids, lead salts (petrol engines) and water.

(6) Coolant leakage—from gaskets, a porous block casting, core plug washers, etc.

Deposit types

Deposits vary in nature depending on their constituents, the temperatures at which they are formed, and the mechanical activity, if any, at the point of deposition. Petrol engine combustion chamber "carbon," for example, consists of fuel soot, oil and fuel "coke," dust, grit and lead salts, all joined by the "coke" into a hard, adhering mass, especially on piston heads. Similar materials constitute ring-groove and oil-drain hole deposits but they become softer and more pasty in the lower piston areas where temperatures are lower. Combustion by-products are generally a constituent of these deposits, especially under low-temperature operation. They contribute to the resins that act as binders.

Varnish and lacquer formers, initially existing as oil-soluble materials, are converted to thin, adhering, almost glass-like coatings on cylinder walls and piston skirts, and in bearings, due to further chemical change and the polishing motion of the affected parts. "Hot" sludges of various forms, also arising from the oil-soluble combustion products, appear on the other parts of the engine. "Cold" or mayonnaise-like sludges, in which water is always a constituent, appear in crankcase, valve chambers and other relatively cool engine parts. Valve-stem and guide deposits range from sludges to "carbon" in accordance with the temperature prevailing at the point of appearance.

Obviously, those deposits which are most critical are those that interfere with engine operation and performance. Freely-moving piston rings, for example, are necessary properly to confine and utilize compression and combustion pressures, and to minimize blow-by which reduces power, increases oil consumption, and permits contamination of the oil with fuel and combustion gases.

Moreover, clear slotted oil-control rings favourably affect oil economy and combustion-chamber deposit tendencies. Valves and valve lifters, especially the hydraulic type, must be unimpeded in their action by deposits, to ensure proper opening, seating and timing. Those low-temperature sludges which deposit in the inactive engine areas are the least troublesome generally. However, they can form in oil-ways, causing reduced flow, and also act as an insulating film, thus intensifying any local heat-radiation problem.

So far as engine operation is concerned, effective detergent action is most apparent and beneficial in preventing or greatly minimizing deposits on such areas as cylinder walls and pistons, in piston ring grooves and oil-drain openings, bearings, hydraulic valve lifter interiors, etc.

What is detergency?

Lubricating oil detergents are effective principally because of their action on deposit-forming materials of an organic nature—that is, the deterioration products of the lubricating oil and the various fuel-combustion products. A detergent does not directly affect the non-organic contaminants such as metallic "fines," dust, grit and scale.

The "mechanics" of engine oil detergency continues to be a debatable subject in many respects, and is hard to explain because of the difficulties of comprehending the exact scope and sequence of the various phenomena involved. However, it is believed that a few generally accepted principles have been revealed through recent work in the Vacuum Oil Company, Ltd. laboratories and by other investigators. In substance, there are apparently two phases of detergent activity involved: one a high-temperature phase to counteract the deposit-forming tendencies resulting from lubricating oil deterioration (oxidation), the other a low-temperature phase directed at minimizing the deposit-forming tendencies resulting from the presence in the oil of fuel-combustion residues.

These latter residues tend to increase at low engine temperatures and thus intensify the deposit problem.

High-temperature phase. The chief result of lubricating oil deterioration at high temperatures is the formation of products that deposit from the oil as lacquers, in the absence of detergency. An effective detergent minimizes such lacquer deposits by an interrupting action on the extensive chain of chemical reactions which produces lacquer-formers from new oil. The chain consists of several successive reactions during which various organic compounds are produced. Certain of the steps in this chain are critical with respect to lacquer formation—if they can be altered effectively, lacquer deposition will not result. A proper detergent can accomplish this by participating in reactions resulting in the formation of new, non-deposit-forming materials. In brief, the organic compounds most prone to result in lacquer combine with the detergent to produce relatively soluble and harmless metal-containing compounds which are non-lacquering. The most attractive heavy-duty detergents are those which contain metallic compounds.

There is another probable mechanism by which metal-containing detergents minimize lacquering and deposits in the higher engine temperature zones, such as the piston ring belt and skirt areas. This is by loose chemical combination, or so-called adsorption of the detergent on the metal surface, which acts to minimize the adhesion of lacquer-forming materials to the piston and rings.

Low-temperature phase. Detergents act in the low-temperature phase through another mechanism. The primary low-temperature deposits are principally fuel-induced. Initially, they are soluble in the oil when it is hot. However, their solubility decreases when the parent oil strikes relatively cold surfaces, and precipitation and deposition occur. These deposits are first laid down as soft sludges, and remain so on inactive areas. They may, however, be converted to a lacquer if they are subsequently exposed to higher temperature and the mechanical glazing resulting from the relative motion of close-fitting parts, as on the piston skirt and cylinder wall.

A detergent effective in minimizing fuel deposits from the causes just described does so simply by increasing the "solubilizing" effect of the oil—and the higher the detergent effect, the greater the oil's capacity for entrainment and suspension of the fuel-induced deposit-formers. The detergent component of heavy-duty oils offers supplementary advantages in some instances. Reserve alkalinity, which tends to neutralize organic acids as well as sulphurous acids, and adsorbing ability assist usefully in combating corrosion-promoted engine wear at low temperatures.

Purging

It is evident from the foregoing that an oil with detergent ability prevents or retards harmful deposit formations. Nothing has been advanced regarding ability to clean an engine previously fouled while using a non-detergent or only nominally detergent oil. This statement may be hard to accept, in view of what has been written during the past fifteen years. Reasonable proof that detergent oils prevent or retard deposits, rather than remove them, is furnished by experiment and many years of observation.

In the Vacuum Oil Company Ltd. laboratories, engines have been deliberately run under accelerated fouling conditions with non-detergent oils, causing heavy deposits to be formed. These engines, when subsequently operated on effective detergent oils without prior deposit removal, showed no pronounced or sudden removal of deposits. Periodic inspection revealed only a gradual removal of deposits, principally from parts subjected to "rubbing" action. Widespread field tests have also been carried out to confirm this evidence. Only one logical explanation is possible. The detergent ability of heavy-duty oils reduced the rate of new deposit formation to a very low level, while the "rubbing" slowly wore away the existing deposits. The phenomenon was not apparent, or only slightly so, on the "inactive" engine parts prone to sludge accumulations; improvement in the condition of pistons, rings, and cylinder walls, the areas in relative motion, was measurably and significantly greater.

When detergent oils were first introduced, the universal lack of knowledge concerning the actual mechanism of detergency led oil marketers generally to warn against the possibility of sudden and heavy removal of accumulated deposits. It was feared that the freed deposits would load oil filters, cause large increases in running clearances, clog oil-pump screens, oil holes and lines, thereby leading to engine failure from lack of lubrication. It is unfortunate that these fears have persisted, because they have proved to be without foundation.

The term "purging," which in itself merely means a cleansing or removal, has also been given an undesirable and misleading use in discussions relating to detergency. Many view "purging" in the sense of a cathartic action exclusively, by which large amounts of deposit are moved in bulk in relatively short time from places like valve covers, valve chambers, crankcase walls or ring grooves, and are transported by the oil to other parts of the engine, causing the difficulties mentioned in the previous paragraph.

The facts clearly indicate that there are no laboratory or satisfactory field data, with which we are familar, which demonstrate that heavy-duty oils of any existing detergency level, up to and including Delvac S-200 Series (Superior Lubricant Series 2), have a cathartic action which can lead to lubrication failure or promote high oil consumption. Our experience shows the reverse to be true. For example, some field staff can recall cases where early heavy-duty oils were charged to engines so loaded with deposits that it was necessary to poke a stick into the drain hole after removing the drain plug before the old oil could be drained from the engine. No "purging" of such units was ever authenticated. This also proved true as oils of much greater detergency, such as the Series 2 oil, later came into use. In a recent series of confirmatory field tests, care was taken to select vehicles covering a wide range of accumulated mileages and deposit condition since their last overhaul. In all these vehicles the detergent oil was charged completely to engines without any cleaning and there was no trouble due to this cause. In addition, a detergent heavy-duty oil was in distribution secretly for about a year without complaints of any kind being received from dealers or consumers.

Work done on commercial crankcase cleaners in the United States also furnishes indirect evidence that "purging" with heavy-duty oils does not occur. It was found that none of the many brands of crankcase cleaners investigated gave appreciable benefit in deposit removal despite the fact that these chemical combinations were designed to remove the deposits quickly and completely. Since those products failed to have a rapid cleaning effect, it is hard to understand how the relatively mild detergents used in lubricating oils can accomplish what the powerful chemical cleaners were unable to do.

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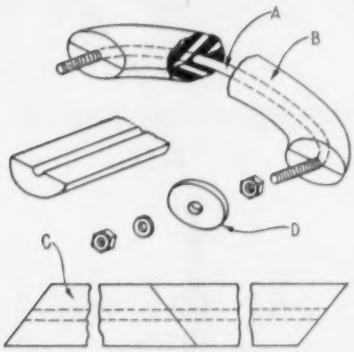
CURRENT PATENTS

A Review of Recent Automobile Specifications

Door-mounted arm rest

THIS method of fabricating loop-type arm rests that also serve as door pulls is claimed to reduce production costs. To a hoop-shaped steel rod A, two lengths of sponge rubber B are applied and joined at their flat faces with adhesive. These items are cut from a straight length of sponge rubber moulding of semi-elliptical section, in the manner indicated at C to avoid waste. A nut is screwed on each protruding end of rod A to constitute an abutment and followed by a wooden flange D conforming to the elliptical section of the sponge rubber padding. This flange is secured in position by a nut and washer.



No. 717885

A sleeve of leather or trim fabric, produced by stitching together two strips of material and reversing to conceal the seams, is then drawn over the padding and the ends turned over and tacked to the flanges D. Alternatively, the two strips may be stitched together at one edge only and then wrapped around the padding and secured by adhesive. In modified constructions the padding may consist of an upper half of sponge rubber and a lower half of extruded rubber or of a single sponge-rubber moulding with an axial bore. *Patent No.* 717885. *Morris Motors Ltd.*

Production of parts from self-lubricating metals

IT has been found that so-called self-lubricating metals, produced by sintering metal and graphite powders, do not obey the laws relating to thermal expansion which apply to normal metals and cast alloys at temperatures above 200 deg C. At temperatures above this value the coefficient of expansion is markedly increased and after cooling a permanent expansion is retained. This permanent expansion is greater the higher the temperature to which the metal had been heated and, for example, may amount to between 0·25 to 0·40 per cent for a temperature of 400 deg C. Under such conditions fits and clearances will be seriously affected.

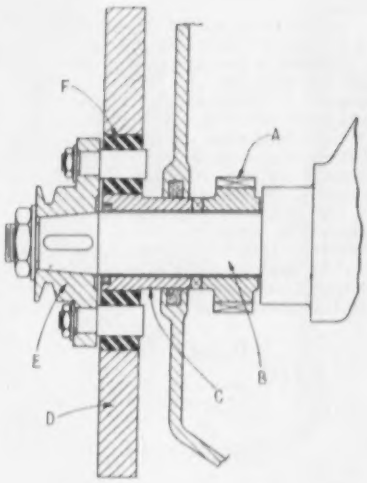
Experiment has shown that if the metal is once heated and cooled a permanent expansion is produced, but if again heated and cooled it returns to the expanded dimensions with accuracy sufficient for all practical purposes. After a further heating and cooling, a complete return is recorded in all cases. It has also been discovered that after a second or further heating the coefficient of expansion again assumes the normal value it had at temperatures below 200 deg C.

The claim, therefore, is for a process of manufacture for self-lubricating metal components for use at temperatures exceeding 200 deg C, characterized by subjecting the metal at least once, or preferably more than once, to heat-treatment at or above the operating temperature, with subsequent cooling, before machining to finished dimensions. *Patent No.* 718719. *Aktiengesellschaft für Bergbau-und-Huttenbedarf (Germany).*

Torsionally damped, resilient drive for engine timing gear

TO obviate the transmission of non-uniform angular velocity and oscillation phenomena from the crankshaft of an engine to the camshaft, a resilient coupling is included in the drive. A feature of this invention is that the coupling, which may incorporate rubber elements, is mounted external to the crankcase, while the gear wheel or sprocket is within the crankcase.

The timing element A (a gear wheel is shown) is mounted freely on the crankshaft B and is coupled by dogs to a member C which likewise is freely mounted. Member C is appropriately formed with a flywheel disc D and serves as a torsional vibration damper. A hub E, which may be formed as a V-belt pulley, is keyed to the end of the crankshaft and transmits the drive to member C by means of pins engaged in rubber bushes F mounted in holes in the flywheel disc D. Several modified arrangements are referred to in the specification. *Patent No.* 719095. *Daimler-Benz A.G. (Germany).*

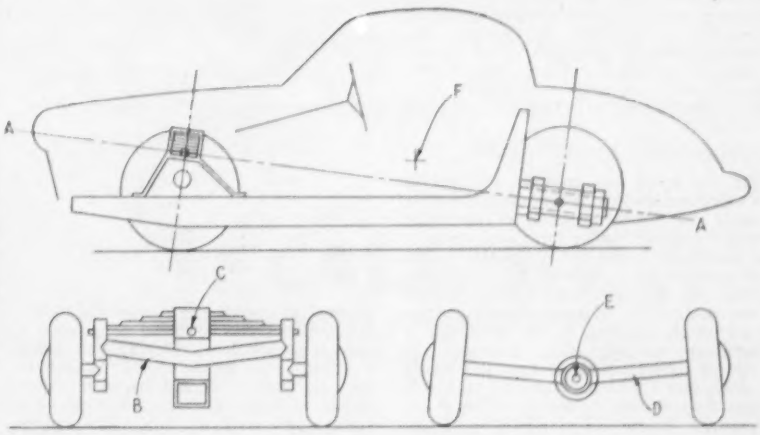


No. 719095

Arrangement of vehicle suspension

WITH the object of obtaining good stability on curves and a smooth, agreeable ride, the role axis A-A on the medial longitudinal plane of the vehicle is inclined from the horizontal and falls from front to rear. The rigid front axle B has its swing centre C located well above the wheel axes while the oscillating half-axles D at the rear are inclined downwardly to give a swing centre E below the wheel axes. Good lateral stability is ensured by arranging for the centre of gravity F of the vehicle to lie closely adjacent to the roll axis.

At least one, but preferably both of the axles, yield resiliently from a forward bottom position to a rearward top position. The movement should be at, or approximately at, right-angles to the roll-axis as indicated. *Patent No.* 718999. *Daimler-Benz A.G. (Germany).*

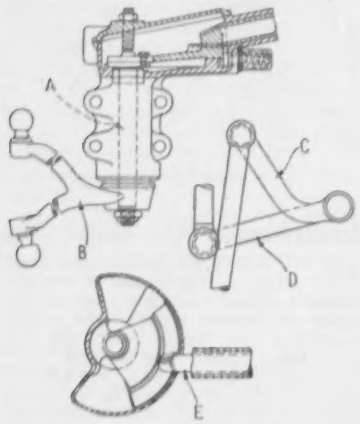


No. 718999

Hypoid bevel steering gear

AN earlier patent, No. 715810, specified a system in which steering motion was transmitted from a bevel sector box to a pair of idling levers actuating a three-part track rod. The present invention constitutes a modification, giving a simpler and more easily accommodated layout.

To the lower end of the main spindle A is secured a forked member B, one arm C of which is bent upwardly and inwardly and the other arm D is bent downwardly. Arm C is connected by a short track rod to the wheel arm on the steering side of the vehicle, while arm D is linked by the longer central track rod to the idling spindle on the opposite side of the vehicle. By the inward bending of arm C the length of the short track rod is about the same as that of the upper wishbone lever of the wheel suspension, and by bending upwardly the track rod is disposed approximately in the same rocking plane as the upper wishbone. The



No. 718697

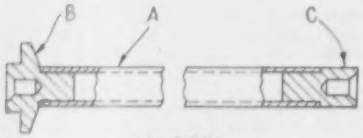
downward bending of arm D permits the central track rod to pass below the engine or the frame of the vehicle.

It is claimed that this is the first application of a hypoid bevel gearing to a steering system. Its use enables a relatively larger pinion to be employed in a relatively smaller box while retaining the same reduction ratio. A further advantage is that the inclination of the steering shaft E can be reduced or, while retaining a previous inclination, the steering box can be located closer to the centre of the vehicle. *Patent No.* 718697. *Bayerische Motoren Werke A.G. (Germany).*

Fuel injector spring spindle

IN the usual fuel injector, the needle valve and the spring spindle reciprocate under the alternate action of hydraulic forces and the spring load, and there is a maximum useful value for the weight of those parts. Should this maximum value be exceeded, operational efficiency may be seriously affected. Needle bounce may occur, resulting in the admission of burnt or partially burnt gas into the injector nozzle. As such gases are highly acidic, they attack the nozzle to an extent that may reduce its useful life to a few hundred hours. The elasticity of the spring spindle also has an influence on the efficiency and should be of a minimum value in order that the spring pressure is transferred quickly and consistently to the needle to ensure a clean cut-off of the fuel on closure.

To obviate these potential disadvantages, particularly in the case of "long reach" injectors, it is proposed to make the spindle of a material having a lower specific gravity and a lower modulus of



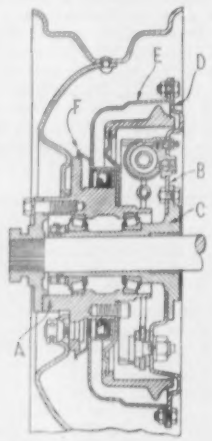
No. 718762

elasticity than the mild steel commonly used for the purpose. The spindle consists of a tube A of an aluminium alloy, such as Duralumin, with a flanged end plug B of hardened steel, on which the spring is seated and a second hardened steel plug C, which is recessed to engage the needle valve.

It is claimed that inertial and kinetic stresses are much reduced as a result of lowered weight and the working life of the valve is greatly increased. Its resilience under compression is approximately 66 per cent less than that of a solid mild steel spindle and consequently the blockage of spray holes by carbon deposits is virtually eliminated. *Patent No.* 718762. *Injection Maintenance Ltd.*

Totally-enclosed vehicle brakes

TO prevent the ingress of water, mud or dust which may deleteriously affect the performance and the working life of wheel brakes, these components are completely enclosed and sealed. The wheel hub A is stepped on its periphery and the brake drum, in this instance a cast drum with a sheet-metal web, is registered on the smaller diameter and bolted up to the shoulder. A brake plate B, mounted in the usual manner on the axle casing



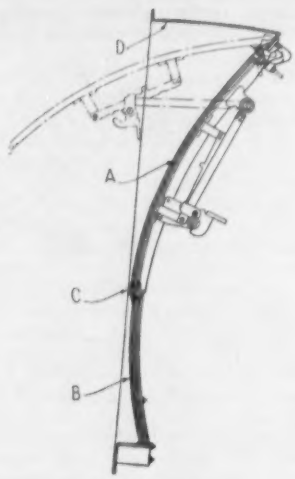
No. 719168

flange C, is channelled to clear the mouth of the drum and extended to provide a circumferential flange D. To this flange is bolted, with an interposed packing to seal the joint, a dished cover E which makes a fluid-tight junction with the major diameter of the hub. The sealing ring is retained in the cover by means of a coned baffle ring F which clears the edge of the hub wheel flange.

The specification contains no reference to heat generated during operation and makes no suggestion as to the method by which such heat may be dissipated to the atmosphere. *Patent No.* 719168. *Bendix Aviation Corp. (U.S.A.).*

Non-reflecting windscreen

IN buses or coaches in which the driving position is not partitioned from the main accommodation space, the usual flat windscreen is liable to reflect light from lamps or other bright objects to the rear, thereby interrupting the view of the road ahead. The invention aims to obviate, or to greatly reduce, the creation of reflected images visible to the driver, without involving any reduction of the seating capacity in a body of maximum permitted length. Accordingly, the windscreen, or a front window, is curved in a



No. 719119

vertical direction with the concave surface presented rearwardly. The transparent panel is mounted in a pan to form a self-contained unit adapted to be set in an aperture in the front of the vehicle body.

In the example illustrated, the panel is divided horizontally into upper and lower portions A and B, the upper portion being hingedly mounted in known manner. They are mounted in correspondingly curved glazing frames and slightly overlapped at the junction C. The exact form of curvature will depend on the characteristics of the vehicle and will require to be designed to suit specific applications. Generally it will be found that the chord between the top and bottom edges of the upper panel portion should not be less than 24 deg to a vertical plane depending from the top edge.

It is desirable that the horizontal glazing bars at junction C are given a dull black finish in order to prevent a line of reflected light from being visible to the driver. Any type of adjustable staying mechanism for the upper panel may be used. That shown is the subject of another patent, No. 477087.

The pan D is flanged to conform with the front face of the vehicle body and is proportioned to accommodate the panel so that it does not project beyond the body line. *Patent No.* 719119. *Auster Ltd. and W. W. Small.*

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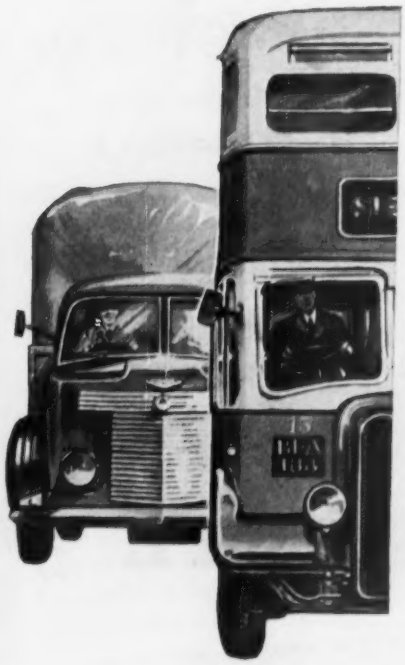

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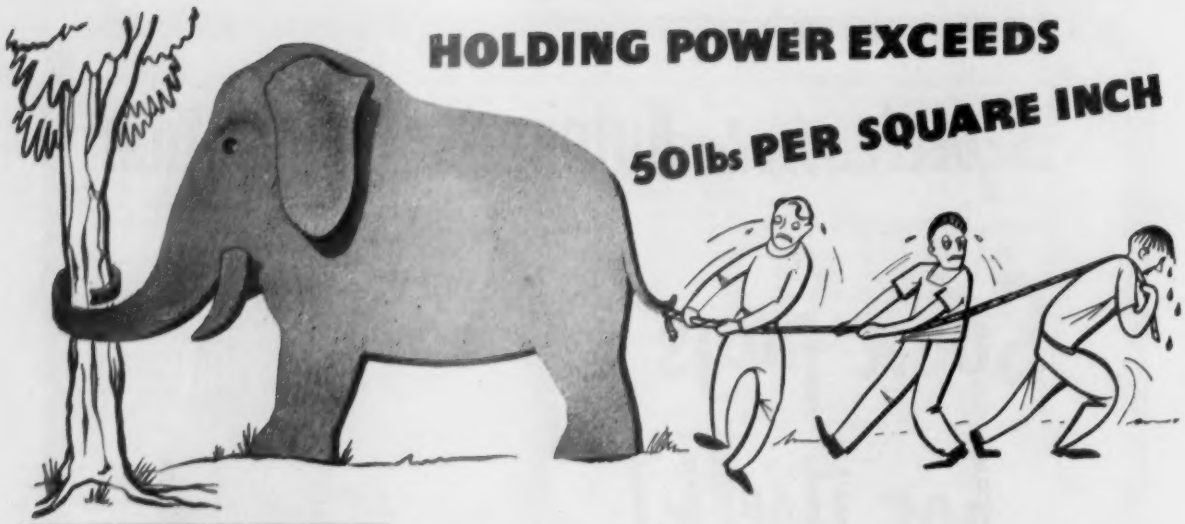

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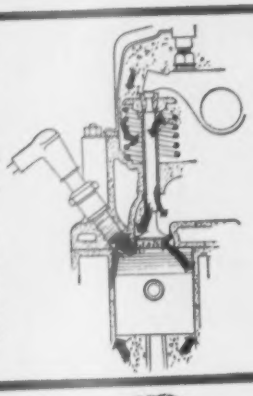

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It may be that the use of a slightly hotter sparking plug would have the desired result, and if not already fitted we suggest a set of Champion N8B plugs. Should these fail then it will be necessary to take action to prevent the excess oil which is causing the fouling from reaching the combustion chambers.

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In the case of oil passing the pistons it will be necessary for an inspection to be made before action can be decided upon, i.e., to determine the condition of the pistons, rings and cylinders. The details given suggest some inefficiency of the piston rings only, and subject to there being no damage or other condition likely to affect the efficient working of the rings, a new set together with a slightly more efficient oil control ring, e.g., the Wellworthy Duaflex ring, should have the desired result.

Austin Magazine, December, 1954

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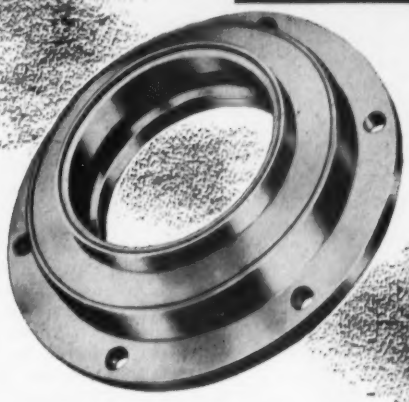

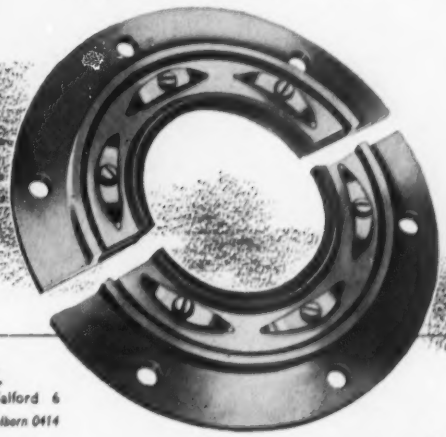

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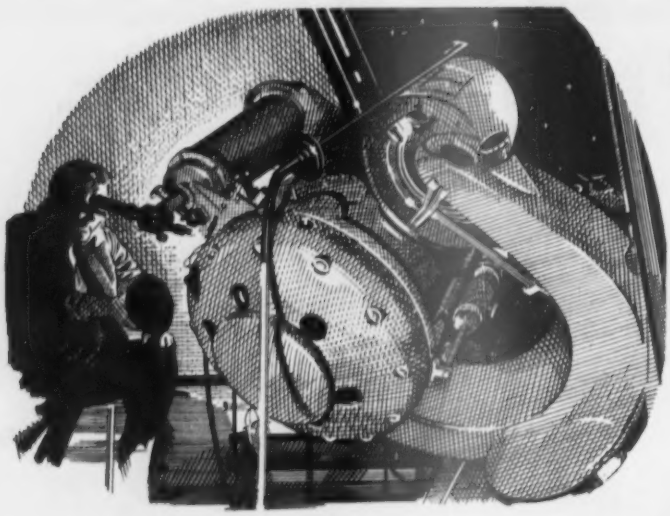

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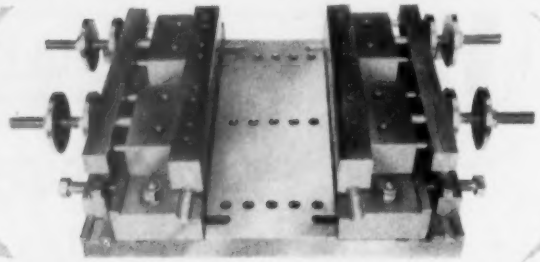

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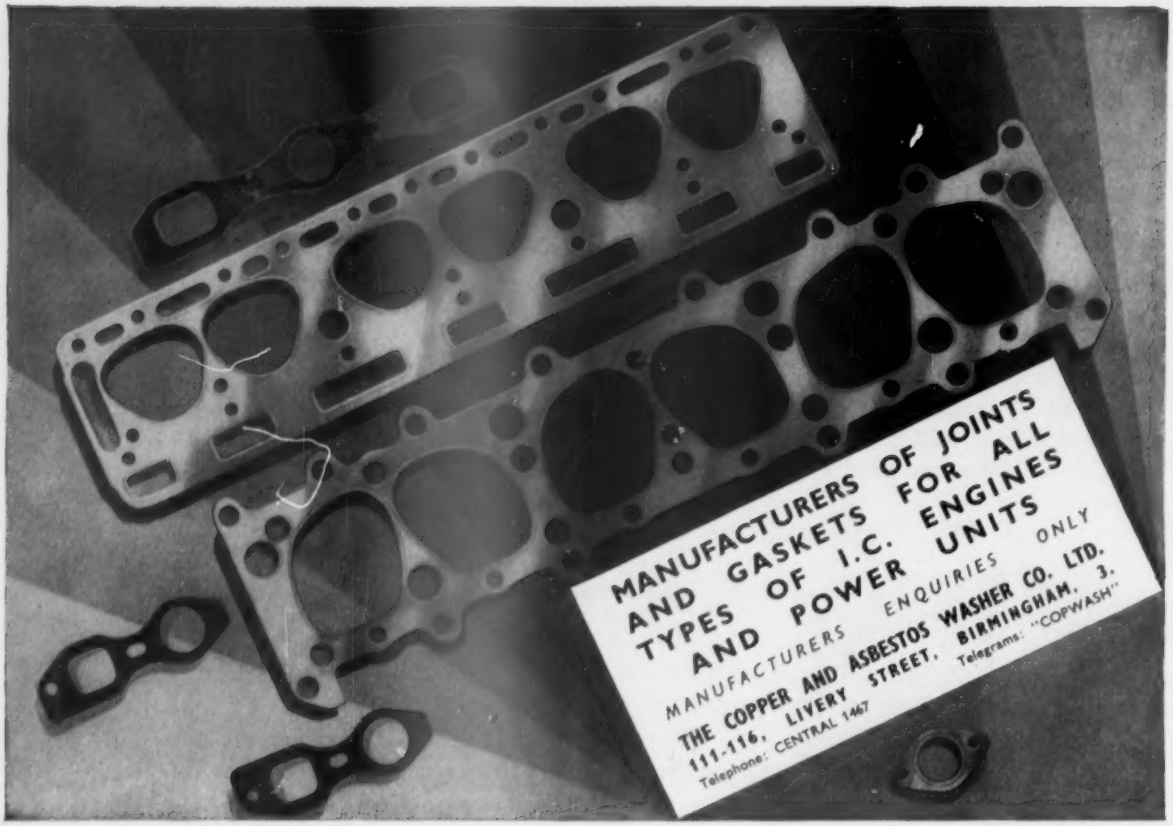
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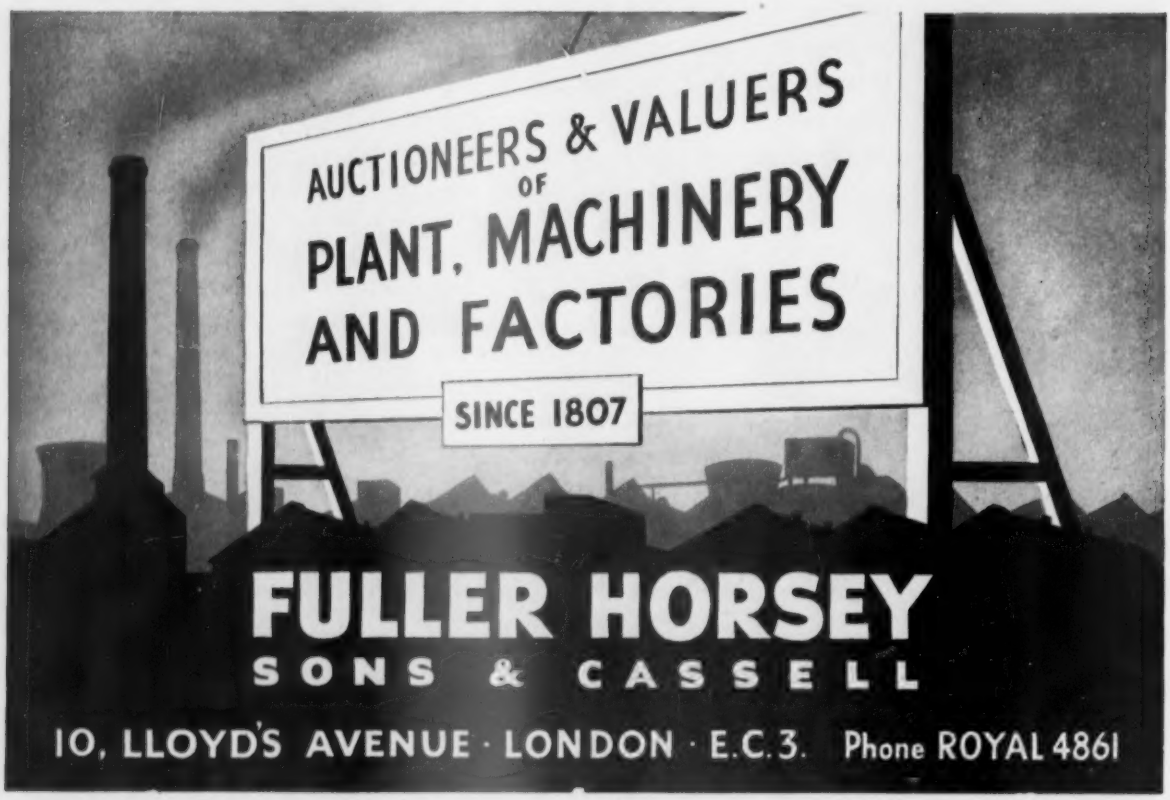
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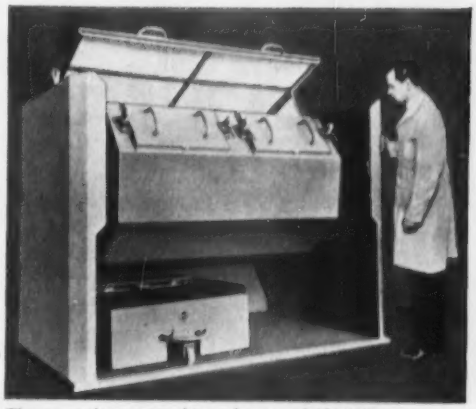

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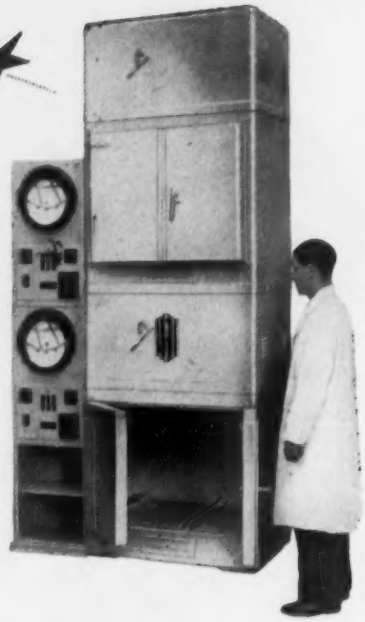

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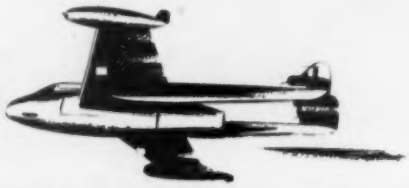

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MODEL 45

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437	133	4
* 542	205	5
* 45	250	5
* 045	250	5
† S450	300	4
* 557CM	350	5

* *These units are available with either an overdrive or direct top gear*

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MODEL 557CM

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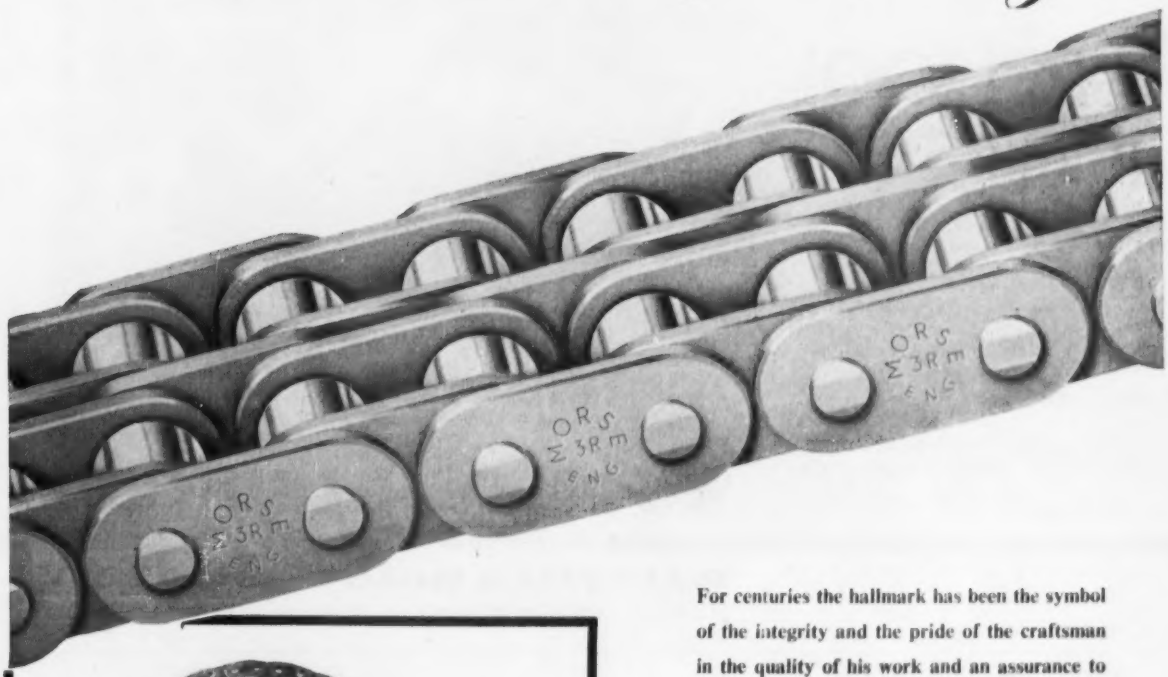

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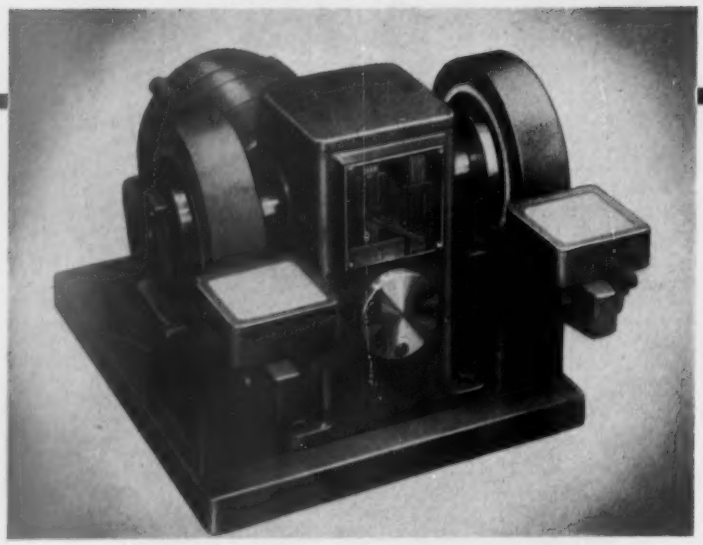

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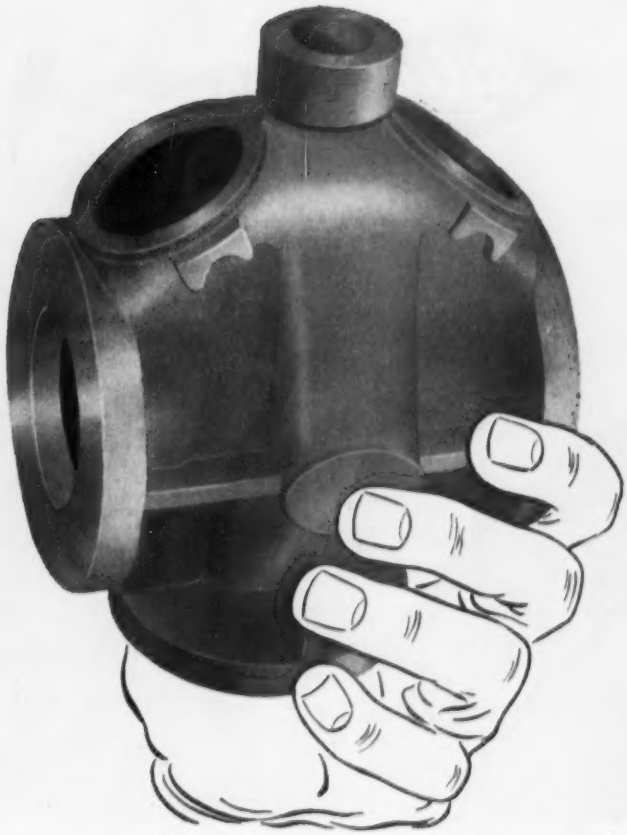

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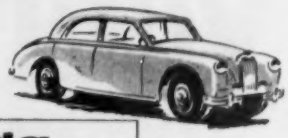

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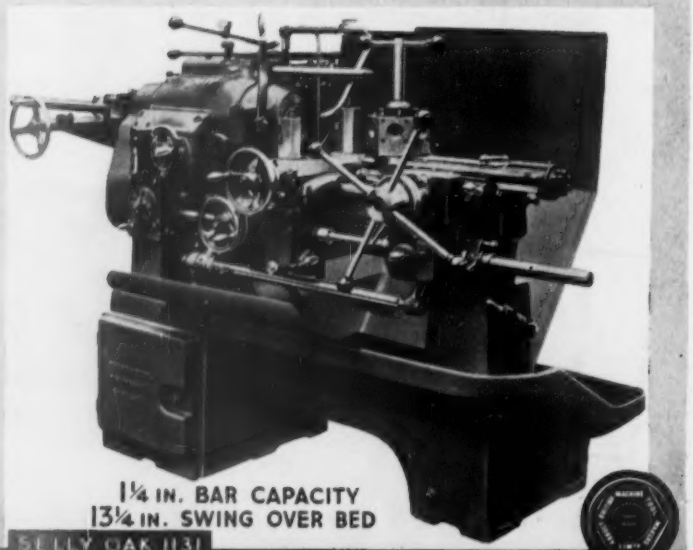

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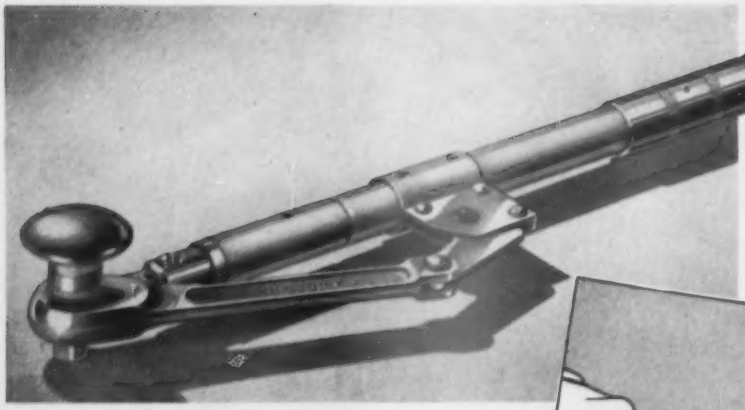
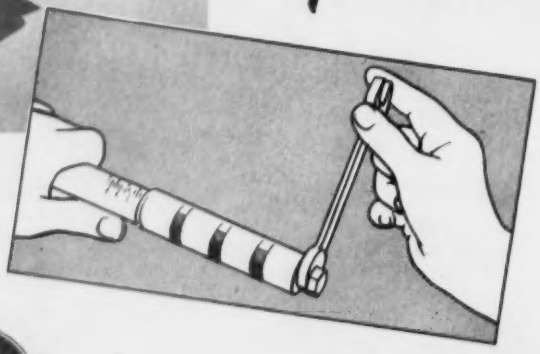


Torque Wrench



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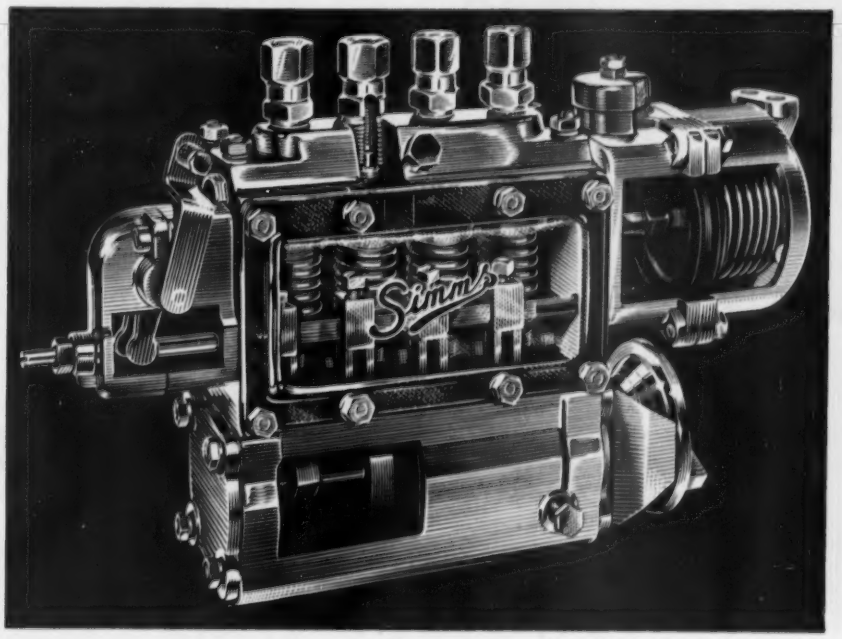

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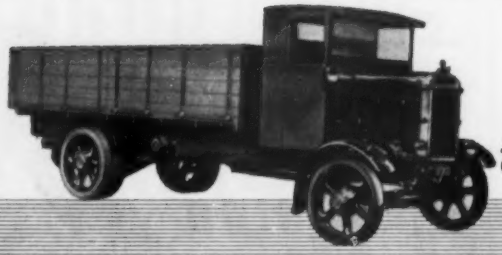

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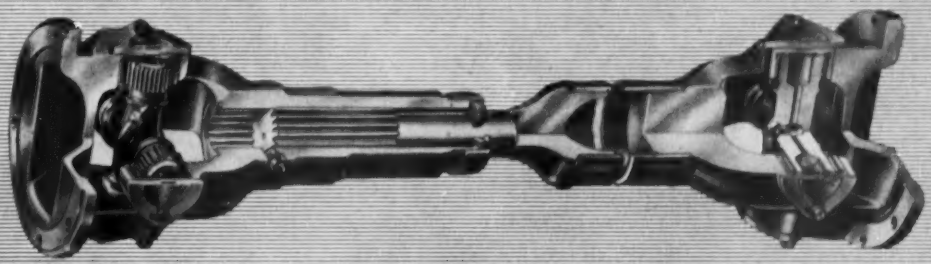

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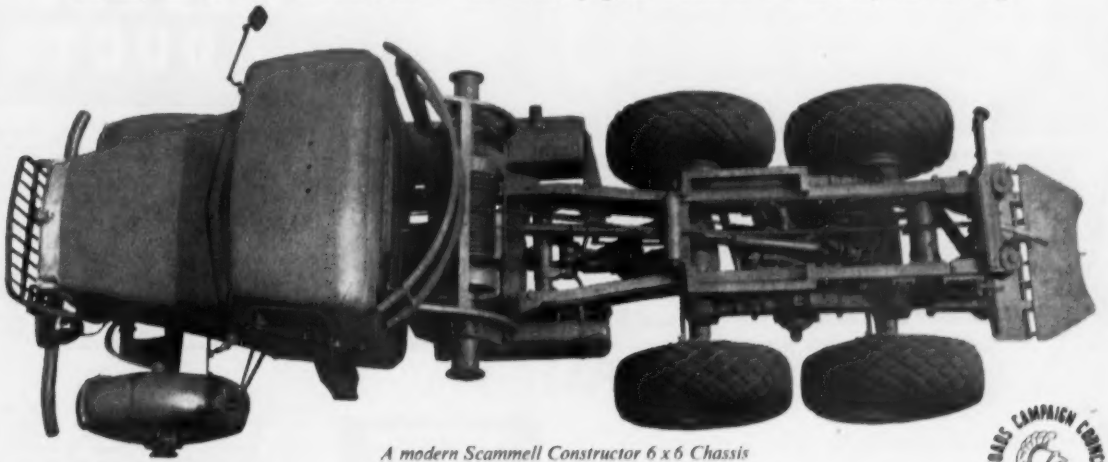

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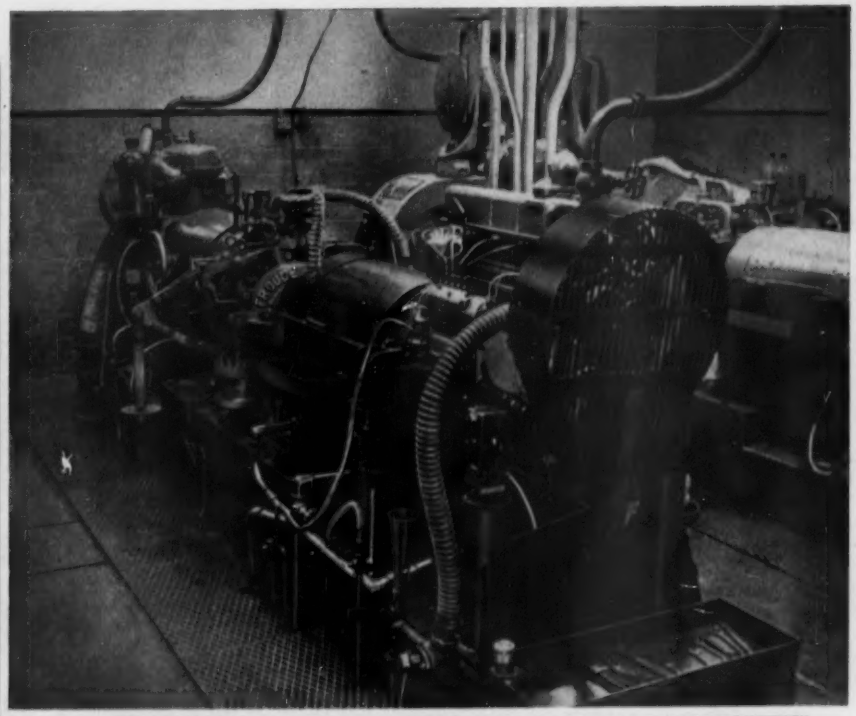

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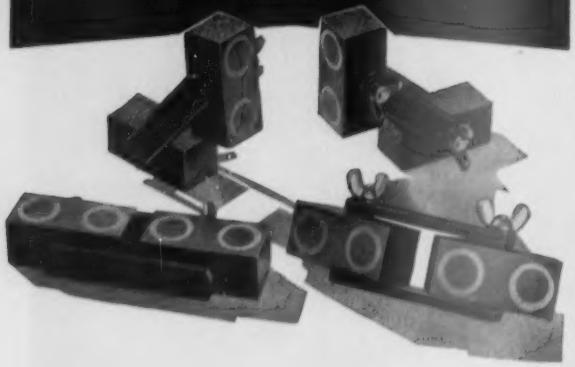

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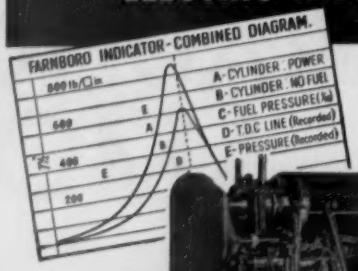
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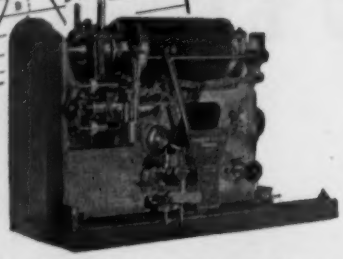

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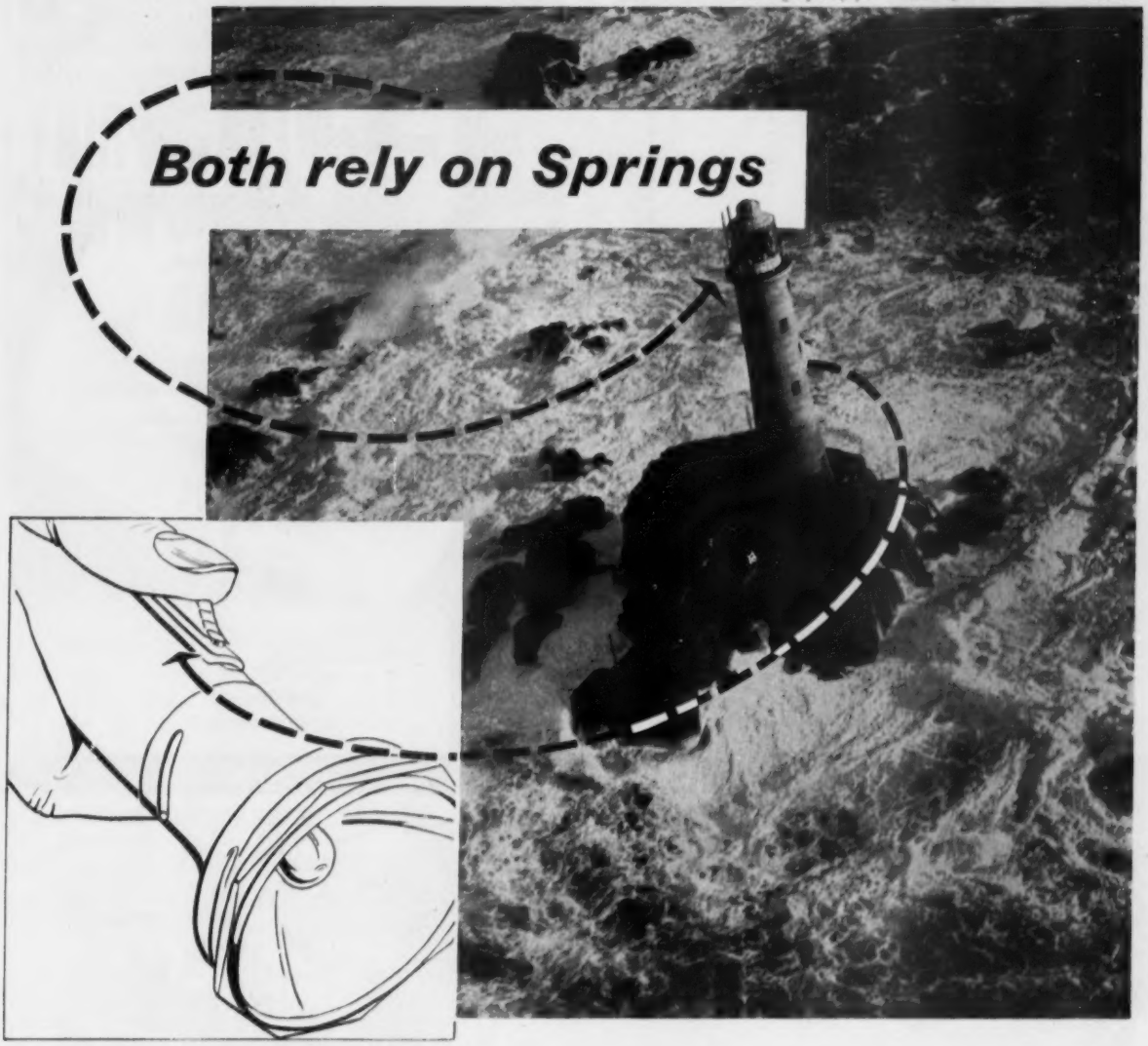

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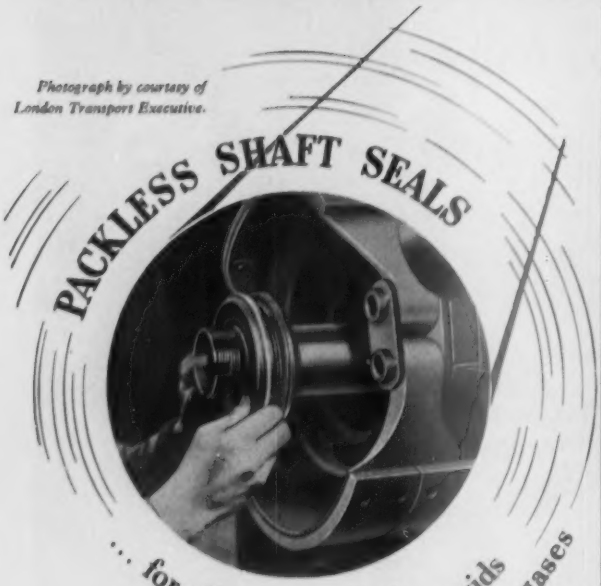

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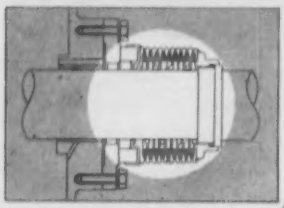

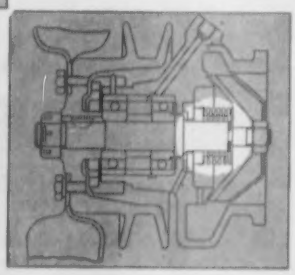

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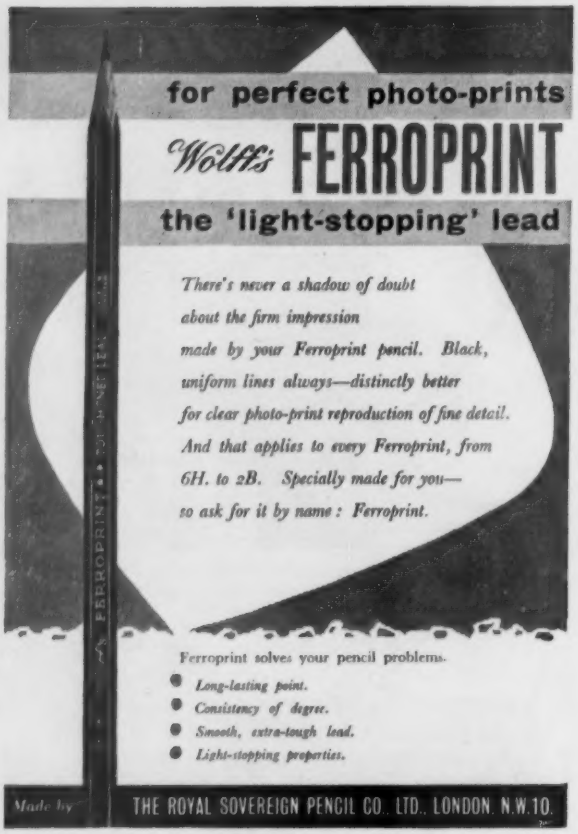
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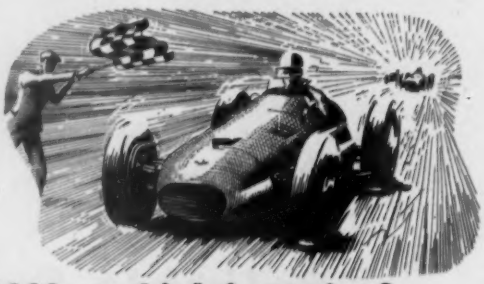

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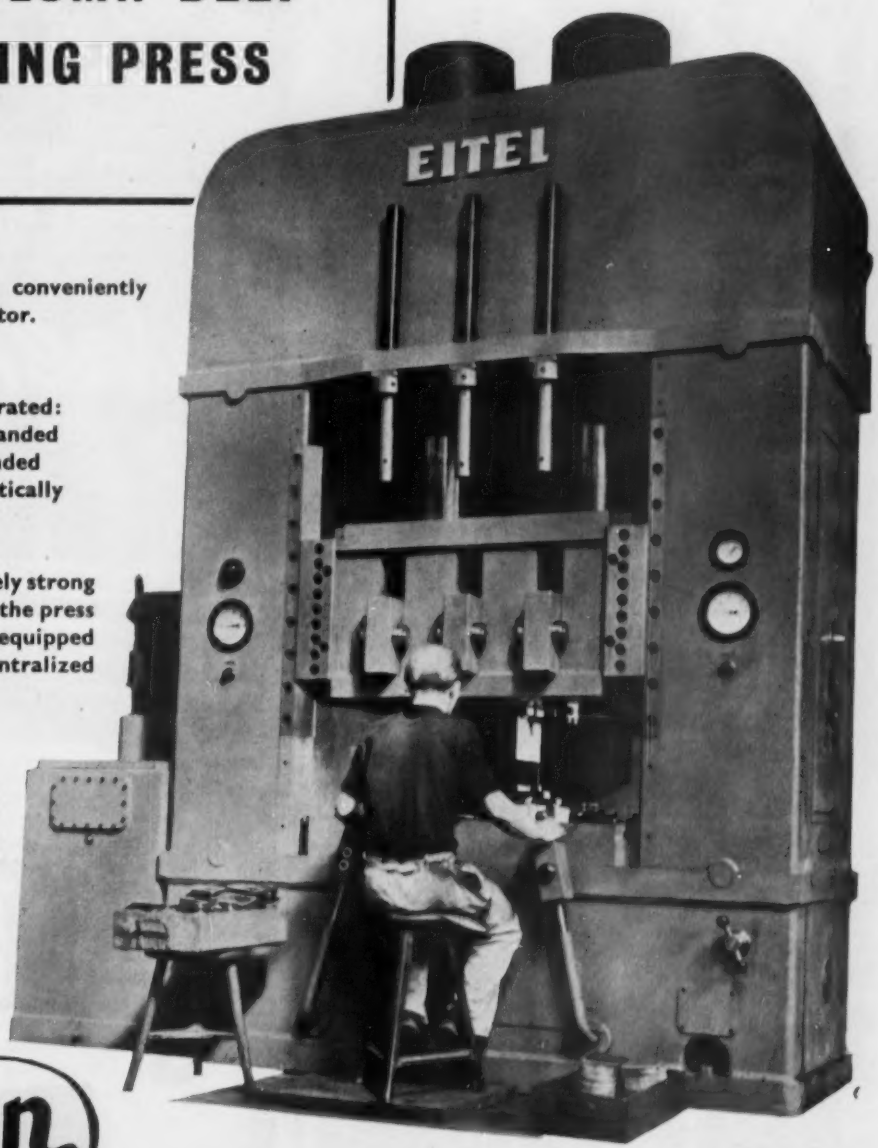

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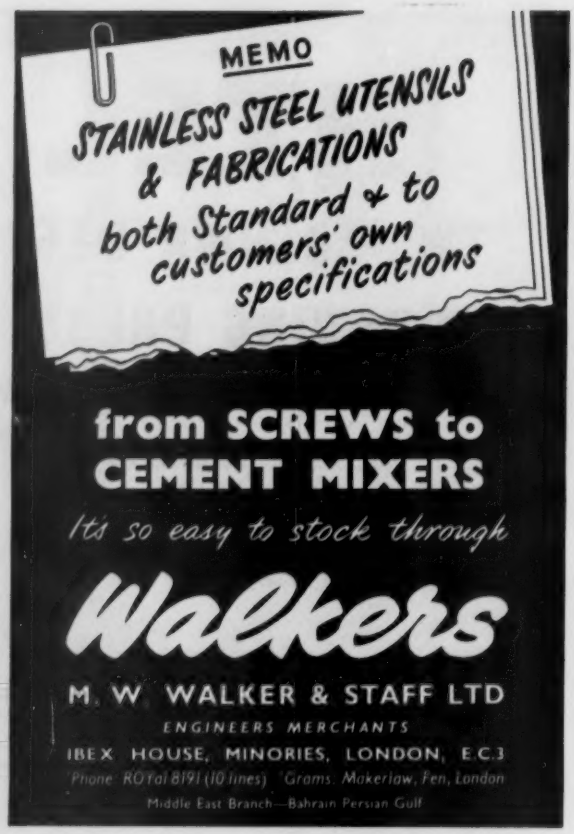
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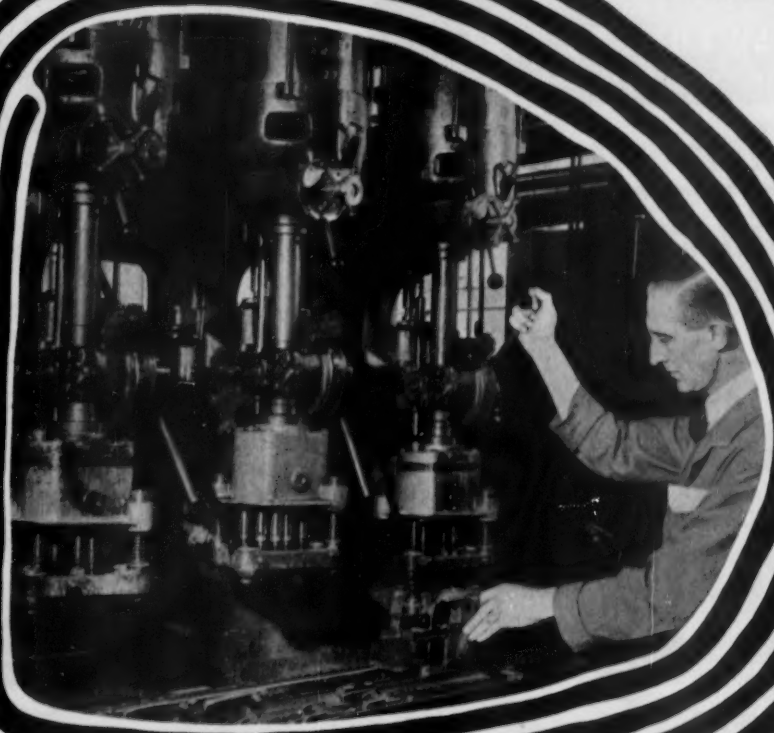

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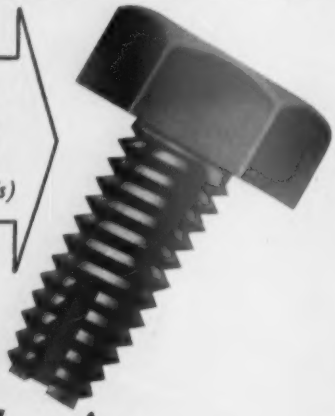

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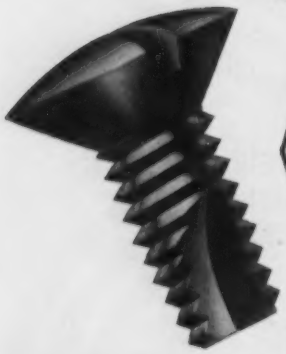

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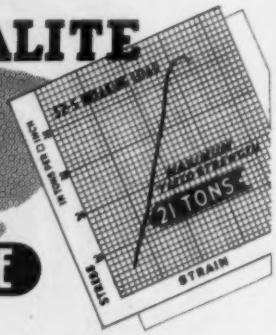

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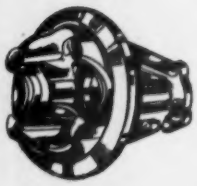

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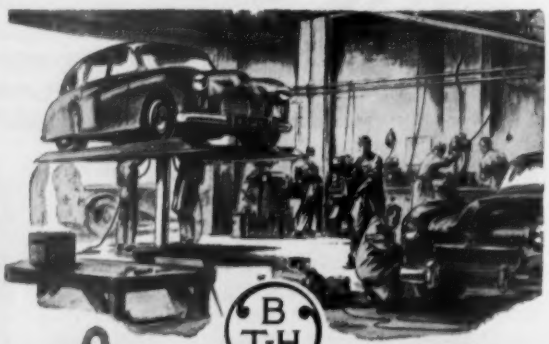

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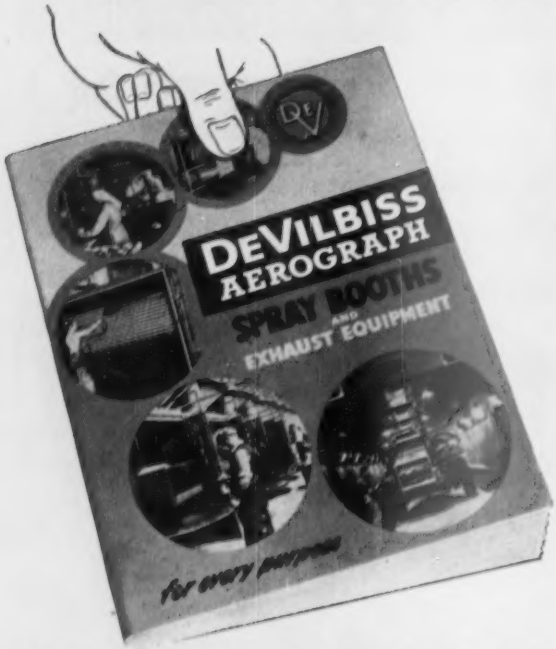

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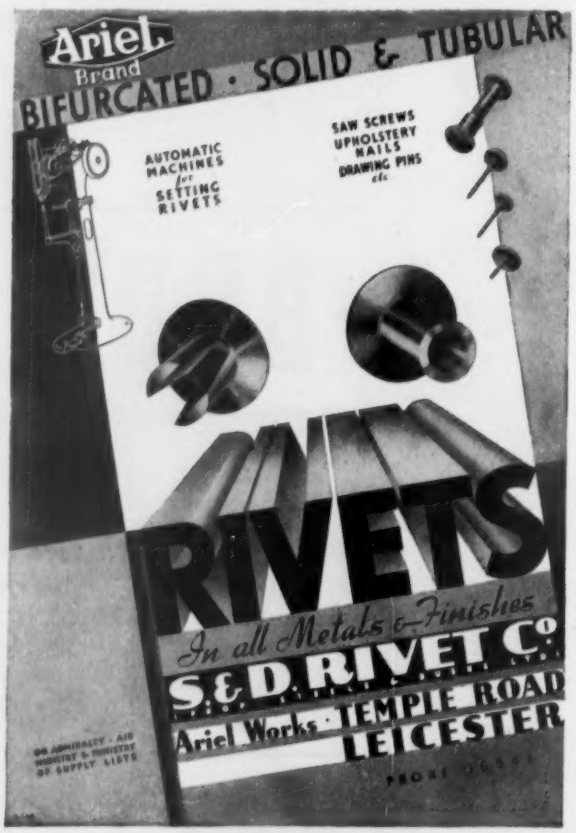

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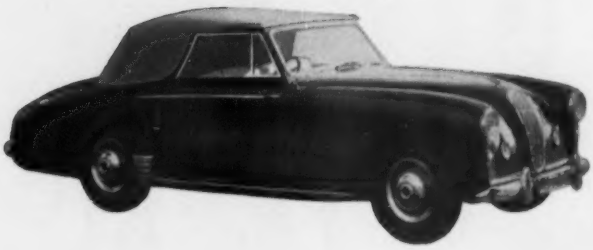

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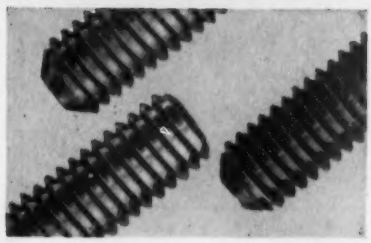

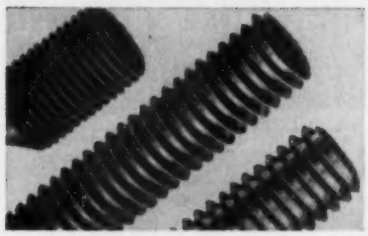

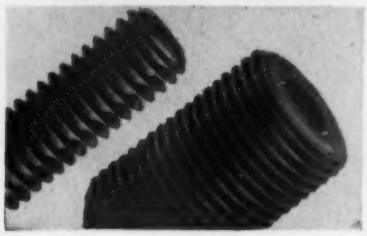

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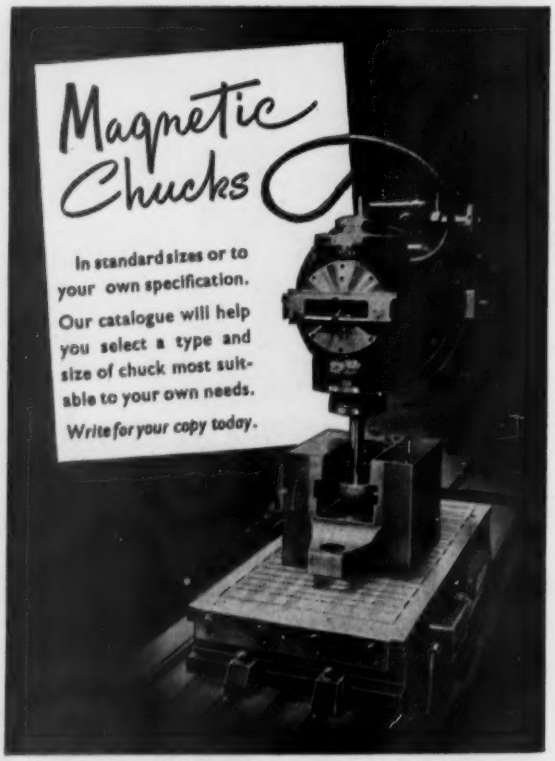
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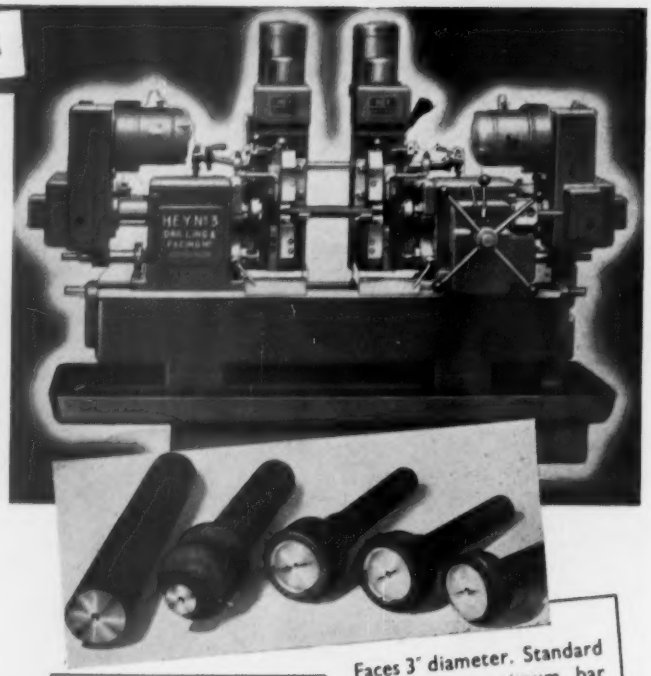

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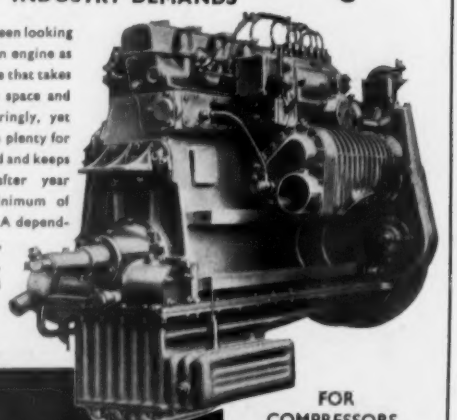

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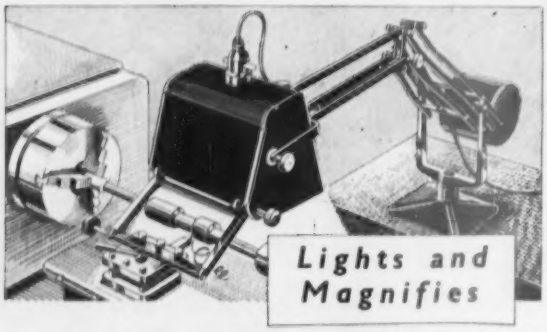

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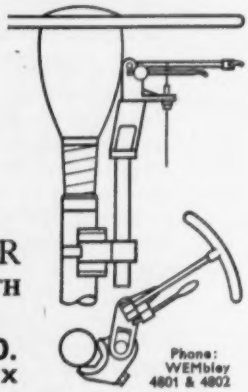

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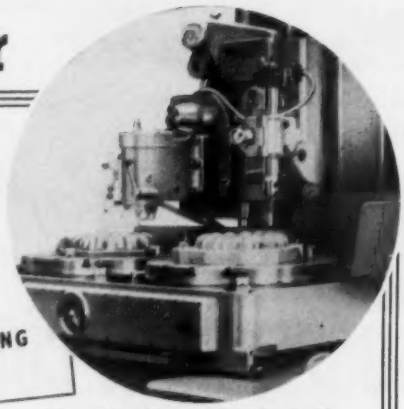

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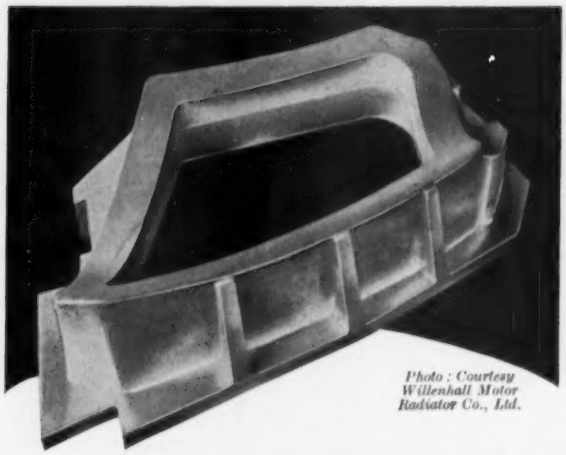

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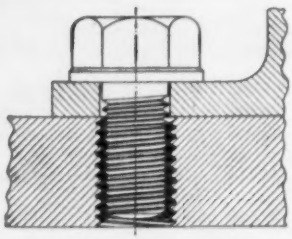

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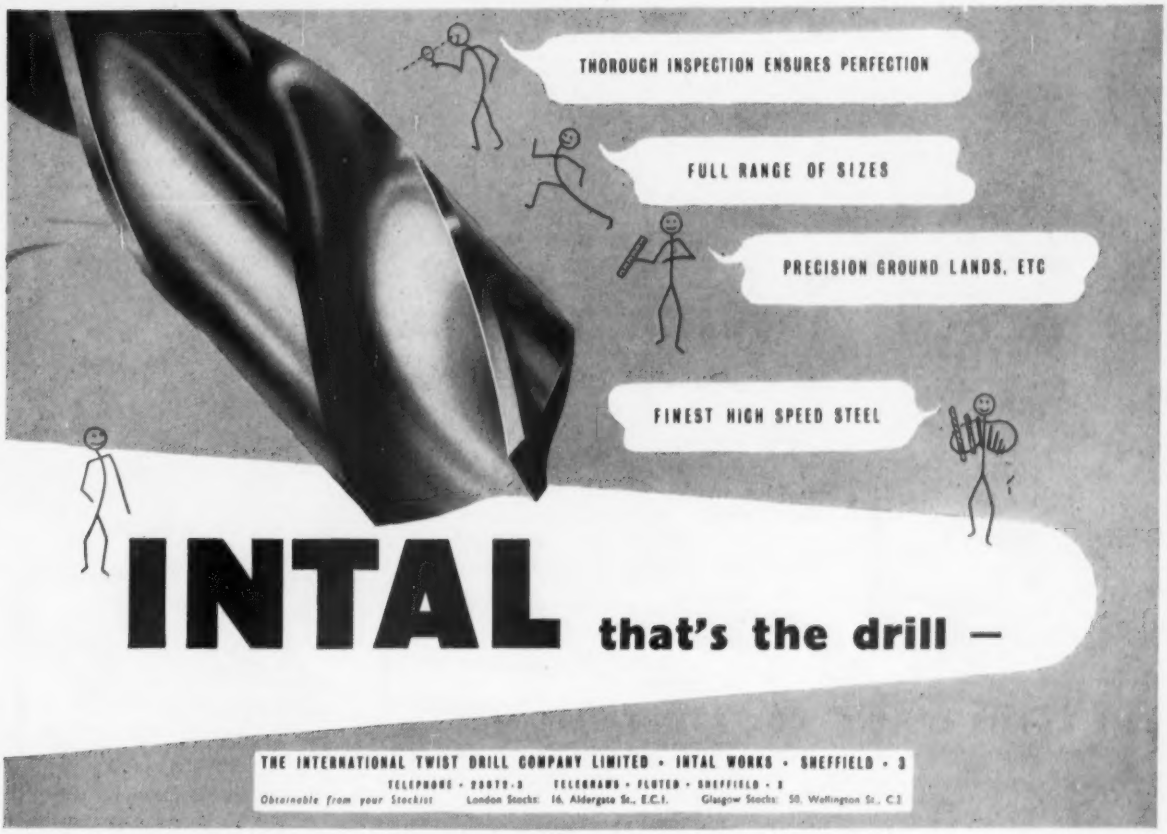

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